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MUNITIONS OF WAR.

NOTE.—*The importance of the subjects discussed in this Report, and the urgent equest of many who are professionally, and otherwise interested in such matters, have induced the compilers to print a limited number of copies on their own responsibility, authority for this purpose having been received from the Secretary of State.*

REPORT

TO THE

Government of the United States

ON THE

MUNITIONS OF WAR

EXHIBITED AT

THE PARIS UNIVERSAL EXHIBITION, 1867.

With Eighty Illustrations.

BY

CHARLES B. NORTON, LATE LIEUT.-COL, U. S. V.,

AND

W. J. VALENTINE, ESQ., PRES. OF U. S. COM., 1855,

United States' Commissioners.

PRINTED BY AUTHORITY.

New York:

OFFICE OF ARMY AND NAVY JOURNAL, 39, PARK ROW.

London:

E. & F. N. SPON, 48, CHARING CROSS.

1868.

231. d. 38.

PREFACE.

THE undersigned, in presenting their Report, desire to express their sincere regret that the Government of the United States had not commissioned some officers of the regular army to fill a position of so much importance—a position, demanding often scientific research, and technical knowledge, such as only the professional soldier or engineer may be expected to attain. The first consideration of the undersigned has been to obtain, and lay before the Government, the best information on all subjects referred to in their Report. So, in order to supplement their own limited knowledge of some of the subjects treated on, they have made a liberal use of such official documents as came within their reach, and also of any published accounts which appeared in the leading scientific and other journals of different nations. In adopting this course, they believe that a more complete view of the entire field has been obtained, than if they had relied solely on their own resources. It is also their duty as well as pleasure to state, that in many cases they have received most valuable information and assistance from Exhibitors, or their Agents. Though they are fully sensible of the danger of trusting to *ex parte* statements in matters of this nature, they believe that the inventor, or maker, is generally best able to describe his own invention, or manufacture; and, as the province of this Report is not to decide upon, or even to recommend, improvements, no danger can possibly result from thus endeavouring to obtain the best information in regard to new inventions.

In dealing with a subject so comprehensive as "War Materials," a certain classification was indispensable; hence, the several divisions, or chapters, embracing Small Arms, Field and Heavy Ordnance, Army Accoutrements, Iron-clads, &c. But owing to the irregularity with which the information and data respecting the several exhibits were obtained, there arose, in certain cases, a necessity to depart, in some degree, from the strict order of classification. The undersigned, feeling it to be their duty to notice (though not on exhibition in Paris) any important improvement or event attracting public attention and bearing on the questions before them, desire to say, that some of these cases also, such as the English trials of the Rodman Gun at Shoeburyness, may appear to be out of place, or treated in a manner too desultory, because these events were transpiring while this Report was being written.

Much, indeed nearly all, that has been said about our 15-inch smooth-bore gun, was written before the trial against the 8-inch Warrior target, with 100lb. charges, which fairly established the superiority of American ordnance. It is a source of much gratification to the undersigned, to find that these experiments fully corroborate the conclusions previously arrived at by their own investigations, as to the high position taken by our country in all that relates to modern gunnery. A single shot from this gun, not only saves many of the following pages from being consigned to the waste-basket, but acts like a spell on the English press at whose suggestion the shot was fired. One of the leading journals, after the first trial with 60lb. charges, said:—"From the spectacle of this cast-iron leviathan heaving its clumsy shot against the 8-inch target, at a distance of 70 yards, utterly unable to penetrate the inner shield, we turn to the contemplation of our 9-inch Woolwich gun, penetrating the same target, at a range of 250 yards." But after the second trial, with 100lb. charges, we find the same journal saying:—"We must frankly admit that we have ourselves, in common with all experienced artillerists of this country, somewhat

underrated the powers of the American ordnance. We did not think that the gun would have achieved this success.....In the next place we doubted the gun's capability of burning so large a charge of powder before the shot left the muzzle, which capability is now fairly established; and finally, we thought it probable that the cast-iron shot, which the Americans employ, would break up. In this too we were mistaken, and the penetration is a *fait accompli.*" The *Times*, to palliate the defeat of the target, says:—" It must not be forgotten that the target had been struck, on previous occasions, by more than 11,000lbs. of iron propelled by about 1,900lbs. of gunpowder." But the writer himself seems to forget, that he is suggesting a most powerful argument against their own ordnance, the American gun having done more damage with one round than the Woolwich guns did with fifty. The 11,000lbs. of iron and 1,900lbs. of powder, used in these guns, merely made a few small round holes not impossible to stop up, which (with the exception, perhaps, of a few men killed and wounded) would leave the ship in fair fighting condition ; but a twentieth part of the powder and iron, when fired from the 15-inch Rodman, made a hole which no ingenuity could possibly stop, and which, in action, would certainly lead to the surrender or destruction of any vessel so protected.

In concluding these prefatory remarks, the undersigned desire to express a hope, that, for practical purposes, the accompanying Report may be published by the War Department as soon as possible after its presentation to Congress.

CHARLES B. NORTON.

Paris, 1867. WM. J. VALENTINE.

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MUNITIONS OF WAR.

CHAPTER I.

CARTRIDGES.

BEFORE adverting to the various systems of breech-loading rifles, it will be necessary to refer to the cartridge, for, in truth, most of the rifles exhibited have been invented to suit the cartridge, instead of the cartridge being devised to suit the rifle. A cartridge containing the means of its own ignition, is, by no means, a recent discovery, for such a cartridge was patented as early as 1831, and in 1836, a Parisian gunmaker introduced the metallic cartridge, which, with certain modifications, is in general use at present, for smooth-bore sporting arms. The needle-gun cartridge has been in use in the Prussian service many years, and though not metallic, it contains its own ignition. But the metallic cartridge for weapons of war, was first largely adopted in our own armies during the rebellion, and was, as already hinted, the parent of many beautiful inventions in breech-loading small arms, both in our own and other countries. In order to compare this with other cartridges, a brief description will be necessary, and for a comparative description of several of the best known cartridges we are chiefly indebted to a paper read by Captain O'Hea, before the Society of Arts in London.

The American is a simple, metallic cartridge, consisting of four parts, namely, the shell, the fulminate, the charge of gunpowder, and the bullet. The shell is formed from one piece of soft copper —is without joining or welding of any kind, being punched or plugged out from the solid metal by machinery, and is, as nearly as possible, of equal substance or thickness throughout, for the purpose of equal expansion. The means of ignition is in the shell, round the rim at the base, and when loaded with the charge of gunpowder, this shell is made to grip the projectile so as to unite it with the gunpowder and fulminate in one compact body. The projectile is solid, and composed altogether of lead. In addition to the small number of its component parts, this cartridge has much to recommend it. It is impervious to moisture, and may even be used after immersion in water. It is gas-tight, for the shell expanding with the combustion of the charge, combined with the resistance offered by the initial movement of the bullet, completely seals the breech, and thus effectually prevents the escape of gas breech-wards. It has the additional advantage, that the copper shell can be re-formed and re-loaded after the contents have been discharged. The original shape of this cartridge-case was cylindrical, with a projection at the base for the fulminate, and to help the extraction of the expanded shell; but some modifications have been brought into use with particular arms, among which may be mentioned the invention of General Roberts. The peculiarity of this cartridge is, that the cylindrical portion of it, which is larger than the bore of the arm, extends into the barrel but a short distance, when the diameter of the chamber, as well as of the shell, lessens slightly, until the latter joins the bullet. This facilitates the extraction of the expanded shell, causes more even expansion, and enables the cartridge to contain a somewhat increased charge of powder.

"The 'Peabody,' 'Cochran,' and 'Hammond,' rifles," says Captain O'Hea, "are the only American breech-loaders I have seen using a metallic cartridge, with a charge of fifty-five or sixty grains of powder. However, this fault in the American cartridge, could easily be rectified. Another peculiarity of American arms using the metallic cartridge is, that the diameter across the base of the projectile used is always greater than that

of the bore of the rifle, measuring from land to land, or the raised portion of the rifling.

Polygonal rifles, such as the Whitworth, are not used in the United States, consequently the bullet is forced to take the grooving as it passes through the barrel. This has its advantages. It is impossible the bullet can strip, avoid taking or leaving the grooves, and I have seldom heard of fractures."

The BOXER cartridge for the Snider rifle, is a compound metallic cartridge, for though, like the American, it consists of but four parts, the shell, the fulminate, the charge of powder, and the projectile, some of those parts are compound in themselves, so that, in truth, it consists of fourteen parts, some of which are doubtless unnecessary. The shell, or cartridge-case, is of two distinct kinds of metal—brass and copper, and in three distinct parts, namely, the base, the coil-shell, and the cap for fulminate; and the projectile is composed of lead, wood, and clay; wood for the centre of the bullet, and clay for the expanding plug. The cylindrical portion of the cartridge-case is formed of a little over two turns of very thin sheet-brass, which is supposed to be expanded, or rather slightly uncoiled, by the explosion, thereby avoiding the danger of fracture of metal by expansion, and of consequent gas escape, even though the cartridge be used in a chamber somewhat larger than its diameter. The base of the cartridge was originally of thin sheet-brass, which was put aside for brass of much greater thickness than the cylindrical portion to which it was welded or soldered, and it had a projection to stop its entering too far into the barrel, as well as to facilitate its extraction. The expansion at the base with the thin sheet was sometimes so great, that if was found impossible, by the ordinary method, to extract the empty cartridge-case; hence the change to a thicker base, also of brass, which has now given place to a base of iron. The weight of the cartridge, without the powder, is now about 200 grains. It has, therefore, been necessary to reduce the weight of the bullet at the expense of the utility of the weapon, and the secret of the conflicting reports made to the House of Commons on the efficiency of this cartridge is, that in the several trials a continual change of cartridge had been made—the powder and ball charge were

The American is a simple, metallic cartridge, consisting of four parts—namely, the shell, the fulminate, the charge of gunpowder, and the bullet. The shell is formed from one piece of soft copper—without soldering or welding of any kind, being punched [illegible] from the solid metal by machinery, and is, as nearly as possible, of the same substance or thickness throughout, for the purpose of expansion. The means of ignition is [illegible] at the base, and when loaded with the [illegible] this shell is made to grip the projectile [illegible] with the grains, wire and fulminate in one compact [illegible] and composed altogether of [illegible] its component parts, this [illegible] It is impervious to moisture [illegible] immersion in water. It is [illegible] with the combustion of the charge [illegible] influenced by the initial movement [illegible] breech, and thus effectually [illegible] It has the additional [illegible] can be re-formed and re-loaded [illegible] The original shape of [illegible] with a projection at the base [illegible] of the expanded shell [illegible] can use with partial [illegible] the invention of General [illegible] is that the cylinder [illegible] of the arm, extending [illegible] the diameter of the [illegible] until the latter [illegible] of the expanded [illegible] enables the cartridge to [illegible]

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C. HAY,

Inspector-General of Musketry.

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weighing 480 grains."

Hythe, 15th Feb. 1867.

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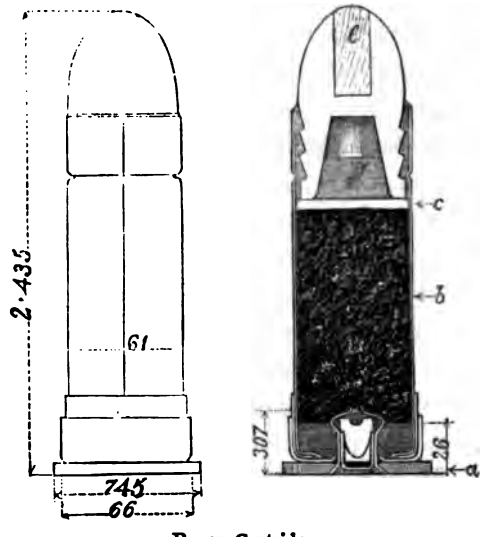
sharp blow it could pass, more or less, entirely into the

constantly varied. This cartridge now consists of the iron base *a*, and the brass shell *b*, as shown in the woodcut. As the brass shell is not soldered to the iron base, a pasteboard wad surrounds the cap and fits to the bottom to prevent the escape of gas, and between the powder and the bullet there is another wad of cotton-wool *c*. In the centre of the base-piece is fixed a cap of copper, which contains the means of igniting the charge, and from which the cartridge derives its name, central-fire. For the purpose of retaining in the new projectile (although decreased in weight fifty grains), the length and figure of the old, as also with a view to place the greater weight as far as possible from the centre of rotation, the bullet has a picket of wood *e*, running through its centre, half-way from the apex of the cone towards the base. At the base is a cavity, containing an expanding plug of baked earth *d*, which latter is also intended as a support to the sides after expansion. As was a necessity with the old muzzle-loaders, the bullet for the present breech-loading arm is still made smaller than the bore, and depends for expansion into the grooves, on the plug of baked clay at the base. The cartridge is covered with a paper covering, attached by gum to protect it from damp. We are not aware that this cartridge-case can be re-primed and charged after being once used. The charge of powder is seventy-five grains, and the weight of sixty rounds is about six pounds ten ounces. With reference to the efficiency of this cartridge, we give the Report of the Inspector-General of Musketry, which was printed by order of Parliament on the 22nd of February last, and is as follows:—



Boxer Cartridge.

"Report of the shooting of the Snider breech-loading long rifle, with the new or No. 3 pattern cartridges, bullet weighing 480 grains."

"Hythe, 15th Feb. 1867.

"Sir,—In obedience to the instructions contained in your letter of the 29th ultimo, I have made a trial of the "central-fire ball cartridges made up with a shorter, or 480 grains bullet, called "pattern No. 3," with the Snider breech-loading long rifle, and have now the honour to report, for the information of His Royal Highness the Field Marshal commanding-in-chief, that the shooting at 600 yards is equal to, and at 800 yards better, than that of the muzzle-loading long Enfield rifle, pattern 1853, with ordinary ammunition, vide table as per margin. I would remark, however, that the angle of elevation with the Snider rifle, is considerably greater, at both distances, than the Enfield rifle, pattern 1853, although the bullet is fifty grains lighter. I need hardly observe, that while the curve of the trajectory is considerably increased (a serious defect in a military arm), the penetration, owing to the decrease of the momentum of bullets, must be considerably less than with the ordinary muzzle-loading ammunition. In several instances the cartridge-case stuck fast and could not be removed without the ramrod. The rifle fouled considerably, and in one or two instances there was a slight escape of gas, which did not, however, interfere with the working of the breech-block. I have no doubt that these defects will be easily overcome when the process of manufacture is better understood. The weather has been very unsettled, hence the delay in making the trial in question and this report consequent thereon.—I have, etc.,

C. HAY,

Inspector-General of Musketry.

Though some of the defects of this cartridge have been overcome since the date of the above report, it seems strange that the British Government should persevere at great expense in endeavouring to improve a very faulty cartridge,* when a superior

* Lord Bury narrowly escaped being killed by the explosion of a Boxer cartridge quite recently. He says, "At the first shot the rifle exploded at the breech, blowing away the covering of the breech and twisting the internal works, I found myself on the ground bleeding profusely and the cartilage of my nose broken. . . . . From the appearance of the cartridge it is evident that the primary cause of the accident is the bursting of the metal base of the cartridge." In one of Col. Boxer's latest Patent Specifications he says, "In the arrangement heretofore employed, the anvil has been made of such a form that if the cartridge was subjected to a sufficiently sharp blow it could pass, more or less, entirely into the

article is already in the market, and suitable to the regulation arm. We allude to the cartridge lately invented by Mr. Daw of London, a compound cartridge, and which, amongst recent inventions, is worthy of special mention, as containing some peculiarities of novel and ingenious description. The cartridge is composed of four parts, two of which are compound. The bullet, as in the Boxer, has the wooden picket through half its longer axis, and the clay plug in the base for expansion. The shell is also of brass, and in three parts, retaining the copper cap for the fulminate in the centre of the base. In almost all other respects this cartridge differs materially from the Boxer. It is much shorter than the present service cartridge, and the inventor consequently claims for it greater facility of extraction from the regulation arm. The cylindrical portion of the case is composed of a little over one fold of thin metal, which, being united, is perfectly gas-tight, and from the slightness of this one fold, of little or no weight, and of great flexibility and toughness. The latter is a marked advantage over stouter metal, as the case, on the ignition of the charge, cannot fail to take the form of the breech, or chamber, in which it is enclosed, and cannot impede, in the least, the extraction of the shell after the explosion, as the sudden alteration of the temperature, after the gas leaves the barrel, causes a slight contraction of the metallic shell. It is waterproof as well as gas-tight, requiring no paper covering or lubrication, as, in addition to the shell being joined by cement or solder, it grips the bullet closely above the cannelures, or grooves, and thus the projectile, with the powder and fulminate, are held together in one compact body by the slight shell. The weight of sixty rounds of this cartridge is five pounds eleven ounces, the weight of bullet 465 grains, that of shell and fulminate 105 grains, and the charge of gunpowder is sixty-five grains.

The Chassepot cartridge is not, correctly speaking, a metallic cartridge. As described in the specification, it consists of

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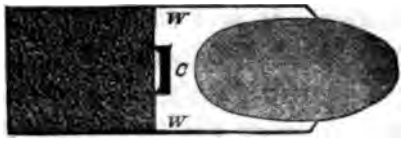
percussion cap, so as to strike against the fulminating compound, and thus explode the cartridge." The improvements introduced in this patent were intended to cure this and other defects of the cartridge, but the accident to Lord Bury, and the recent fatal explosion in the Cartridge Factory at Woolwich, show that the Boxer cartridge is still very dangerous to those who have to handle it.

six parts, namely, the priming, the powder-case, the powder, the pasteboard wad, the ball-case, and the ball. The priming consists of a copper cap, like the ordinary military percussion cap, but of smaller dimensions. It is formed at the bottom with two holes, diametrically opposite each other, intended to give free passage to the charge of powder for the spark, or flash, the fulminating powder being placed at the bottom of this cap; a small plug of cloth or wax covers it, so as to protect it from external concussion. The cap is then covered with a thin washer of brass, copper, or other metal, which is pasted upon, or attached to paper for forming the base of the cartridge, and the priming is thus complete. The powder-case is formed from a rectangular piece of paper, rolled upon a mandril, and pasted at the edges. When the case is dry the priming is inserted with a mandril, and the end of the case is then closed and pasted. The case being thus prepared, the charge of powder is inserted, and is pushed down gently to give rigidity to the cartridge. A pasteboard wad is next placed on the powder, formed with a hole, into which the twisted end of the paper of the case is inserted, the excess of paper being cut off. The ball-case is composed of a paper jacket, having two folds of paper pasted and closed at one end only. The ball is of an elongated tapered form, with a flange at the base. After placing the ball in its case, this case is connected to the powder-case, by a string or thread passed round a groove on each case, a slight distance behind the wad. Finally, the cartridge is greased.

The cartridge of the *Zündnadelgewehr*, or Prussian needle-gun, is peculiarly its own; made for this gun, it can only be used in it, or in a gun having a needle arrangement to reach the fulminate through the powder. It consists mainly of four parts, not enclosed in a metallic, but a paper cover. These parts are the powder, the fulminating cap, the carrier-wad, and the bullet. The latter is of an acorn shape, and weighs about an ounce, and the charge of powder is seventy-six grains.

The distinguishing features of this cartridge, as will be seen by the annexed woodcut, are the carrier-wad *w*, and the cap *c*. The carrier-wad is formed of strips of paper, moulded into the proper shape by heavy pressure, and its uses are as follows:—It holds the cap *c*, con-

taining the fulminating compound, protecting it from chemical influence or other injury; it receives the first impulse of the explosion



The Needle Gun Cartridge.

and transmits it to the bullet, thereby economising the force of the powder; it is compressed into the grooves of the rifling and thus imparts a rotary motion to the bullet, which does not itself touch the barrel, and hence the grooves never get clogged with lead; finally, it cleanses the barrel at every discharge of the gun. The wad accompanies the bullet through some fifty or sixty yards of its flight, and about twenty yards from the gun it strikes a target about three or four inches below the bullet-mark, and at this distance will pierce a pine board of over half an inch in thickness, so that, at short range, the gun may be said to carry two projectiles. This, however, may not always be an advantage, as in the case of firing over a line of troops, at some distance in front, the wad might kill or wound a friend instead of a foe. The fulminate of the needle-gun cartridge, was at one time believed to be kept a secret, but it is now generally known to consist of a mixture of chlorate of potash, antimony, and sulphur, in the proportions of five to three, to two of the respective chemicals. As already stated, the cartridge is enveloped in a paper case; this case is almost, if not entirely, consumed by the combustion of the powder, and, to insure its complete consumption, a certain amount of air is provided for, by the air-chamber, or cavity, surrounding the fore-part of the needle-guide, hence there is no empty cartridge to take out of the gun before re-loading. The ignition of the powder from the front is, however, the great feature in the needle-gun, as by this means it is all consumed and rendered effective. But whether this method possesses sufficient advantages over the central-fire, or rim fulminate, to counterbalance the disadvantages attending the delicate and complicated mechanism of the needle-gun, will be better appreciated after the several guns

themselves have been contrasted or compared. As to the comparative merits of central-fire and rim-ignition cartridges, though the former may, in theory, possess some advantages over the latter, yet there are weighty reasons and arguments against the use of the central-fire system specially applicable to the United States, where magazine arms, such as the Spencer, abound. These cartridges cannot with safety be used in magazine arms, if, as at present, they carry a conical projectile, the point of which, in loading, would impinge on, and ignite the cartridge in front while in the magazine.

There are many cartridges in the Exhibition which possess some peculiarity or novelty to recommend them, but to give even a brief description of each, would exceed the limits of a Report of this nature; besides, though these inventions may each possess one or two features of interest, the cartridge must be looked at as a whole, and those have been selected for illustration which experience has proved to combine the most advantages.

Captain O'Hea, in concluding his interesting remarks on cartridges, says:—

"In the metallic, there appear to me in addition to the great essential of a sufficient charge of powder for the diameter and length of the bore and weight of projectile, five other requisites for ensuring a favourable result, or return, in the use of the metallic cartridge.

"1st—that the shell or case be made of such description, or substance, as will ensure its expanding, or contracting, but not fracturing. 2nd—that the shell be formed of one piece, if of soft metal, and of one fold, if of harder or medium metal, and that it be gas-tight, limited as to power of, and space for expansion. 3rd—that the expansion of different metals being unequal, the insertion, in any part of the shell, of any foreign piece of metal, or even of a distinct piece of metal of the same kind, be avoided, as tending to weaken or fracture it, and increase the cost of manufacture; the fulminate ought also to be placed somewhere on the inner surface at the base of the shell, no matter how that surface may be modelled. 4th—that the shell grip the bullet, so that the cartridge may be impervious to moisture, and that the expansion of the shell may be compulsory, or inevitable on the expulsion of the bullet. 5th—that the base of the projectile be of such a diameter that it is not only forced to take the grooves as it enters the rifled portion of the barrel, but that all chance of gas escape round the bullet is impossible, and that the latter contains no foreign substance or body that would make it liable to fracture on being

driven into the bore, or make the manufacture of it complicated or difficult under any circumstances."

These requisites, with the exception of a "sufficient charge of powder"—a defect easily remedied—are all combined in the American cartridge, already referred to. The very thin cylindical case of Mr. Daw's cartridge* possesses some advantages over the heavier shell of the American, but Mr. Daw's is a central-fire cartridge, and therefore unsuited to magazine arms. Like the Boxer it is uncertain whether it can be re-filled after firing, an advantage possessed by the American cartridge, which, combined with its simplicity and cheapness, gives it, in our opinion, the first place among the many cartridges that have come under our observation.

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* The Small Arms Committee have (March, 1868) awarded Mr. Daw the first prize of £400 for his cartridges.

CHAPTER II.

BREECH-LOADING SMALL-ARMS.

THE Prussian *Zündnadelgewehr*, or needle-gun, is on several grounds entitled to the precedence in any notice of breech-loading fire-arms. First, because it has for upwards of twenty years been the regular arm of a great European Power; secondly, on account of the important part which it played in the late war with Austria; and finally, because, unlike breech-loaders generally, it possesses a peculiar mechanical arrangement, and was not invented to suit some particular cartridge previously in use for other arms. The needle-gun is not exhibited by the Prussian Government, but is included among the arms of several private makers of France and other countries.

It is generally believed that the success of this weapon in the late war, was due to the fact of its being a breech-loader, rather than to any virtue dependent on the feature of its construction from which it derives its name, and perhaps any other good breech-loader would have had an equal advantage over the muzzle-loading arm, with which the opposing army was furnished. Besides, the needle-gun was not a novelty to the Prussian soldier, 60,000 of these guns, on an improved plan, having cast-steel barrels, were served out as early as 1841, a hundred men of every battalion of the line being equipped with them, and the use of the gun by the Prussian infantry became general about 1848.

The factories of Spandau, Sömmerada, Erfurt and Danzig, can produce over 100,000 guns annually, and the number possessed by Prussia before the war, amounted to 600,000. The Royal decree justifying the adoption of the needle-gun came from a King who had served a good apprenticeship to the military art, and contained

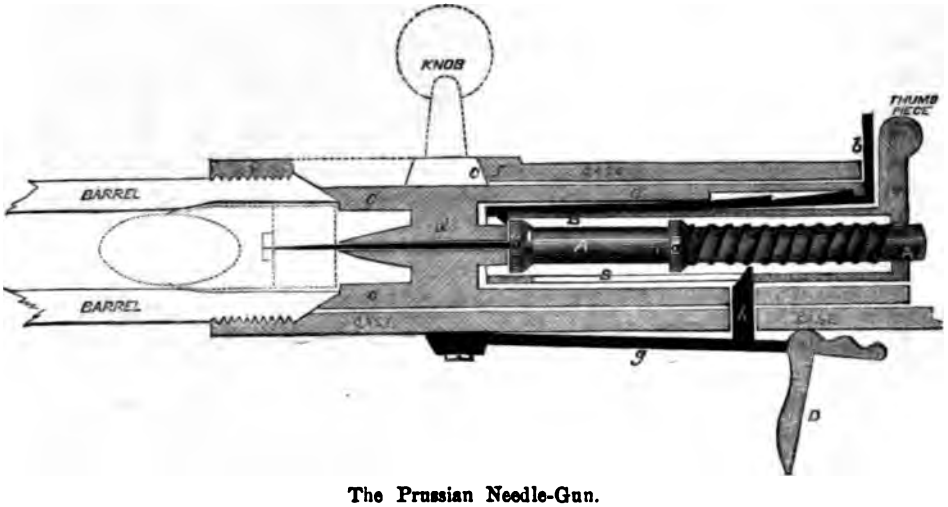
the following passage, which, read in the light afforded by the late war with Austria, seems to have a prophetic import.

"The rifled needle-gun is, according to our present conviction, the perfection of military arms, and its practical introduction will, no doubt, lead to its adoption in all branches of the service. The result of numerous experiments made us appreciate this invention as a special dispensation of Providence for the strengthening of our national resources, and we cherish the hope that the system may be kept secret, until the great part which it is destined to play in history, may couple it with the glory of Prussian arms and the extension of Empire."

The following description of the mechanism of the needle-gun is abridged from a paper in an English periodical (*Once a Week*), and has been verified by examinations of the weapon, as exhibited by the various makers in the Exhibition.

The fundamental principle of the needle-gun, as already stated, lies in this: that a cartridge is employed which contains within itself the fulminating compound that is to ignite the powder, and since this fulminate lies buried between the powder and the bullet, it can only be reached and struck, and hence ignited, by a needle piercing the cartridge. The principal features of the mechanism are as follows:—First (beginning with the feature most notorious) *the needle*, fixed in a holder or bolt, encircled by a spiral spring, the recoil of which is to dart the needle into the explosive charge: second, *the lock*, or appliance for drawing the needle back to put it into connection with the trigger: third, *the chamber*, which forms the breech-piece, and which carries a little tube, or guide, through which the needle passes to the cartridge. The whole of this mechanism is carried in a cylindrical case, which is fixed to the stock by bands, and into which the barrel is screwed, so that the case forms, as it were, a prolongation of the barrel: lastly, there is *the trigger*, which, when pulled, discharges the needle from its detaining catch. How these various parts are disposed, and what is their action, will, we hope, be made clear by the accompanying diagram and the following description. The illustration shows the position of the parts at the moment of firing, just as the needle has struck the fulminate. *A* is the needle-bolt carrying the needle,

and furnished with two shoulders, or projections, *a* and *á*, the hinder part passing through the spiral spring.



The Prussian Needle-Gun.

BB is the lock for drawing the needle-bolt back; it is in the form of a little tube with a projecting *thumb-piece* at one end, and a little tooth or catch (catching the projection *á* of the needle-bolt) at the other; it is, moreover, held in its place by the locking-spring *b*, but can be drawn back when *b* is pressed down.

CC is the chamber, also tubular, in which is fixed the needle-guide *d*. This chamber slides backwards and forwards in the outer case, by an action precisely similar to a street-door bolt, and it is furnished on the outside with a knob or handle by which to move it, bolt-fashion, a slot (not shown in the sectional drawing) being cut lengthwise in it to allow it to pass the catch *h*. Its bevelled or conical end exactly fits the corresponding bevelled or conical end of the barrel, and it is forced into close contact with the latter by a sidewise motion of the knob (bolt-fashion again), which motion, by thrusting the base of the knob *c* against the slightly inclined edge *f* of a slot in the outer case, jams the two bevelled surfaces together, and thus tightly closes the breech.

D is the trigger acting upon the spring *g*, and thus upon the catch *h*. It will be seen that the upper surface of the trigger's

horizontal arm takes its purchase against the under side of the case and that it is furnished with three knuckles or points of pressure; and it will easily be understood that, according as either of these are pressed against the case (by pull upon the trigger), so will the catch *h* be drawn down to a greater distance. The first one is in bearing when the gun is out of use, or immediately after firing; when the second or middle one is brought to bear, the catch *h* is drawn down sufficiently to allow the needle-bolt shoulder *a* to pass over it; when the third is brought to bear, *h* is so far withdrawn that the whole of the lock-tube *BB* will pass over it, so that a soldier can, if necessary, disable his gun in a moment; if he has to retreat, leaving his gun behind him, he merely pulls the trigger very hard and draws *BB* out by the thumb-piece, and he leaves behind him an empty, useless barrel.

These various parts are thus manipulated in the process of loading and firing:—

First, the thumb is pressed upon the spring *b*, and by means of the thumb-piece the small lock-tube is drawn back, pulling with it —by means of the little tooth at the opposite end—the needle-bolt, till the shoulder *a* is caught behind the trigger-catch *h*. Then, by pulling the *knob* a little on one side, and at the same time pushing it towards the butt-end of the stock, the chamber *CC*, with the needle-guide, is slid back, and a clear space is left in that part of the case which is in our drawing occupied by the needle-guide. Through the opening thus made the cartridge is inserted into the end of the barrel, as shown by the dotted lines in the diagram. The chamber is then bolted up again, and the thumb-piece (and so the lock) is pushed forward to its original position. The position of things is then just as shown, with the exception that the needle-bolt, and with it the needle, is held back by the shoulder *a*, catching against the trigger-detent *h*, the spiral spring being of course compressed or in tension. The gun is then ready for firing, the trigger is pulled, *h* is drawn down and the spring, released, darts the needle through the guide into the cartridge, the blunt end of the needle sharply striking the fulminate and thus igniting the charge.

The barrel of the gun is, in the latest pattern, thirty-two inches

long and six-tenths of an inch bore, the breech end being widened out to admit the cartridge easily; and it is rifled with four grooves, three-hundredths of an inch deep, the rifling taking one turn in twenty-eight and a half inches. The total weight of the gun, without the sword-bayonet, is ten pounds and three quarters.

The advantages claimed for the needle-gun are chiefly these: That the bullet is propelled through rifled grooves without violent forcing into the barrel—indeed without coming into contact with it; that the loading is simple and rapid, the ball, powder, and cap being contained in the cartridge; that the loading is from the breech; that the combustion of the powder and cartridge-case is more complete than in any other guns; that the escaping gas carries but little smoke with it; that the gun is instantly disabled, if necessary. Some of these advantages are, of course, common to most breech-loaders; but there is one especial merit in the needle-gun that is not so common to other constructions, and that is the ease with which the mechanism can be made and put together. Concerning the durability of the gun, it is said that many of the battalions of Prussian fusiliers are using now the very guns served out in 1848.

Notwithstanding the many advantages claimed for the needle-gun, and which it has proved itself to possess—at least over the Austrian muzzle-loaders,—it seems to make slow progress in other countries, now that its principles and mechanism are generally known. This cannot be accounted for by supposing that other states have got some satisfactory gun of their own; the late rifle competition at Vienna and the many rifle trials in Great Britain, our own, and other countries show that the various governments, and military men generally, are not satisfied that the victory of the needle-gun is conclusive, or that a sufficiently reliable breech-loader has yet been produced. The chief objections to the needle-gun are doubtless the danger attending the transportation of its paper cartridge, and the delicacy and complication of its mechanical arrangements. The cartridge, unlike the metallic, does not assist in any way to prevent the escape of gas breech-wards, so the junction of the chamber-closer or breech-bolt with the barrel must be a perfect mechanical fit, like the safety-valve of a steam boiler. If a little sand were to get into the joint, an

injurious escape of gas would be inevitable, or if the spiral spring that projects the needle were to come in contact with salt water, the weapon would speedily become ineffective. At the Vienna trials, the Remington rifle was several times covered with dust and left exposed to the influence of damp all night, without interfering with the action of the gun. The Spencer rifle, also, has not only been covered with sand, but immersed in salt water and left exposed for twenty-four hours, and the Report of General—then Captain—Dyer, says, "The rifle was then loaded and fired without difficulty. It was not cleaned during the firing, and it appeared to work as well at the end as at the beginning." The needle-gun, subjected to such treatment, would doubtless be unserviceable, without a thorough cleansing, or if worked with wet sand among its movements the perfect fit of the moveable part to the barrel would be destroyed. Considered mechanically, the needle-gun seems incapable of standing rough usage for a lengthened period, and the late war with Austria was too brief to set this question at rest. Nevertheless, the important part which it took in great battles—rendered decisive chiefly through its agency—and the influence it thus had in shortening the war, will always secure for the needle-gun a careful consideration.

The Spencer rifle, exhibited by the Spencer Repeating-rifle Company of Boston may next claim attention, on account of the important influence it had on the late rebellion. If it has not occupied so prominent or exclusive a position in America, as the needle-gun has in Europe, it was not the fault of the weapon itself, but rather because our longer struggle called many competing weapons into the field, several of which would, doubtless, be able to hold their ground against the needle-gun.

Although the Spencer rifle and its capabilities are better known to the War Department and the American public than to the governments and peoples of Europe, still in a Report in which the arms of other nations will occupy a prominent position, we believe it would be injudicious to pass over, in silence, the efforts made by our own countrymen to bring to a triumphant close one of the most dreadful wars recorded in history. On this war the influence of the Spencer rifle, among new weapons, was of no secondary importance.

This rifle is both a breech-loader and a repeater. Seven cartridges are deposited in a magazine located in the butt of the gun, and are thrown forward to the chamber as required. An ordinarily skilled marksman can discharge the seven loads in twelve seconds, while a platoon of soldiers can fire, with good aim, at the rate of once every three seconds. When the seven charges are fired, the magazine can be refilled in about half the time required to ram and cap the single charge of a muzzle-loading musket. It is important in a repeating rifle to locate the magazine, so that the reserve cartridges should be protected against all danger of explosion. This has been accomplished in the Spencer rifle, by a method that appears to meet the necessity. The magazine has a double sheathing of metal strongly encased in wood, and thus presents almost as formidable an obstacle against external force as the barrel itself. This safety results, in part, from the character of the cartridge used, which is copper-cased, and contains in the most compact form the powder and ball, with the addition of the priming fulminate in the periphery of the base. This cartridge is not injured by exposure to the air, or even by submersion in water, as the powder and fulminate are both hermetically sealed. For safety and certainty in magazine arms, no other cartridge compares with this. Central-fire cartridges with conical projectiles would be dangerous in the Spencer rifle magazine, but it is impossible to explode the rim-fire cartridges, except by a concussion made by the hammer, and when that concussion is made, no other cartridge explodes with such unfailing regularity. By a very simple arrangement, the liability to an explosion before the breech is properly closed is rendered impossible, because the hammer cannot be made to strike the cartridge, nor anything impinging thereon, until the parts are properly locked.

The rifle has frequently been submitted to the judgment of some of the most eminent Ordnance officers of the Army and Navy. Captain—now Admiral—Dahlgren, had the arm thoroughly tested at the Washington Navy yard in June, 1861, and, as the result of his experiments, and report thereon, the Department ordered a considerable number of the rifles for the naval service. In Captain Dahlgren's minute account of his experiments with

the rifle, he says, " The mechanism is compact and strong. The piece was fired five hundred times in succession—partly divided between two mornings. There was but one failure to fire, supposed to be due to the absence of fulminate. *In every other instance the operation was complete.* The mechanism was not cleaned, and yet worked throughout as at first. Not the least foulness on the outside, and *very little within.* The least time of firing seven rounds was ten seconds."

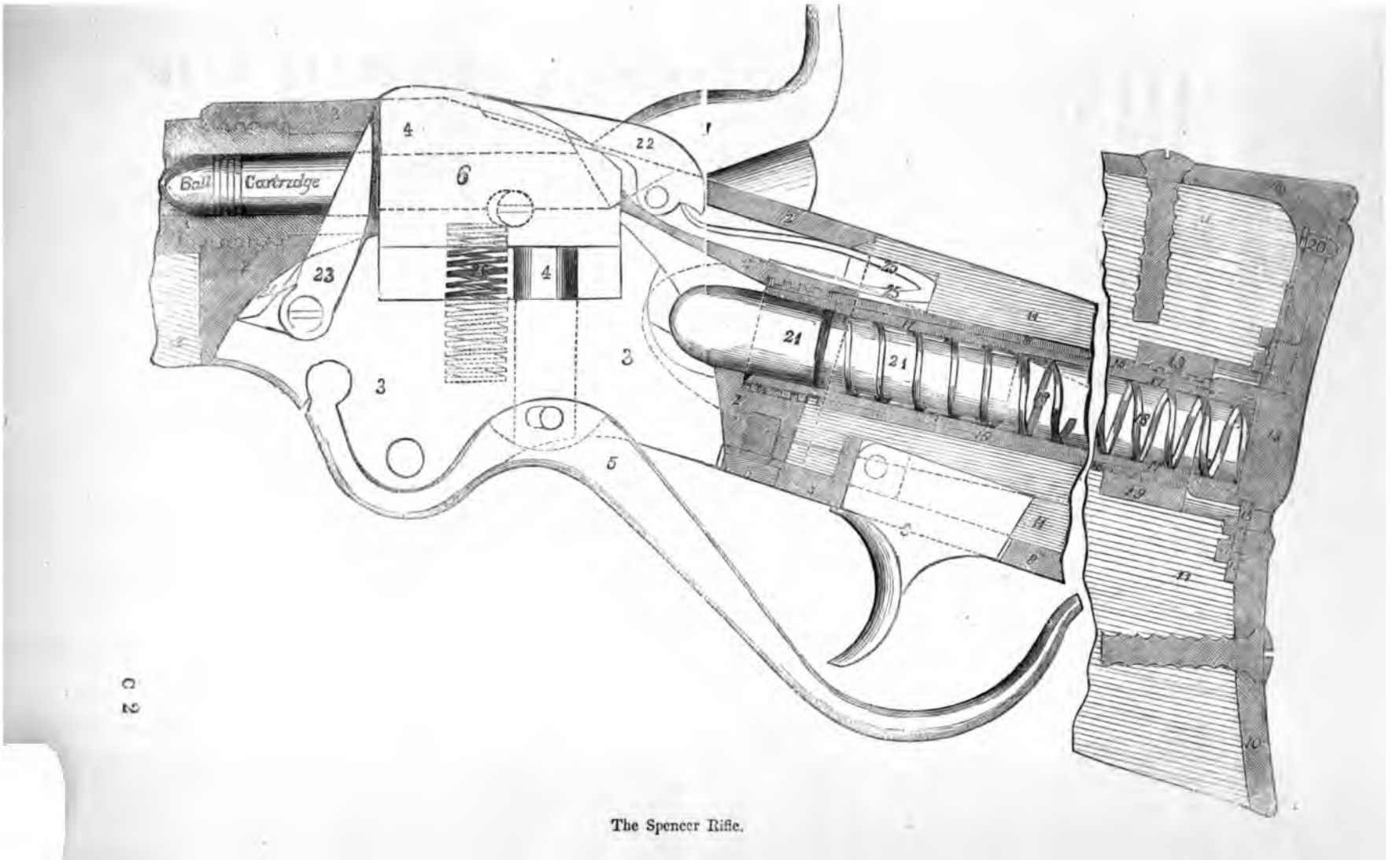
In the following November a board of military officers reported as follows:—" In firing it is accurate ; the range good ; the charge used smaller than is generally used in small calibres; the cartridges, being in copper tubes, are less liable to damage. The rifle is simple and compact in construction, and *less liable to get out of order than any other breech-loading arm now in use.*"

The following directions for loading, with the woodcut opposite, will be sufficient to explain the mechanism of the working parts:—

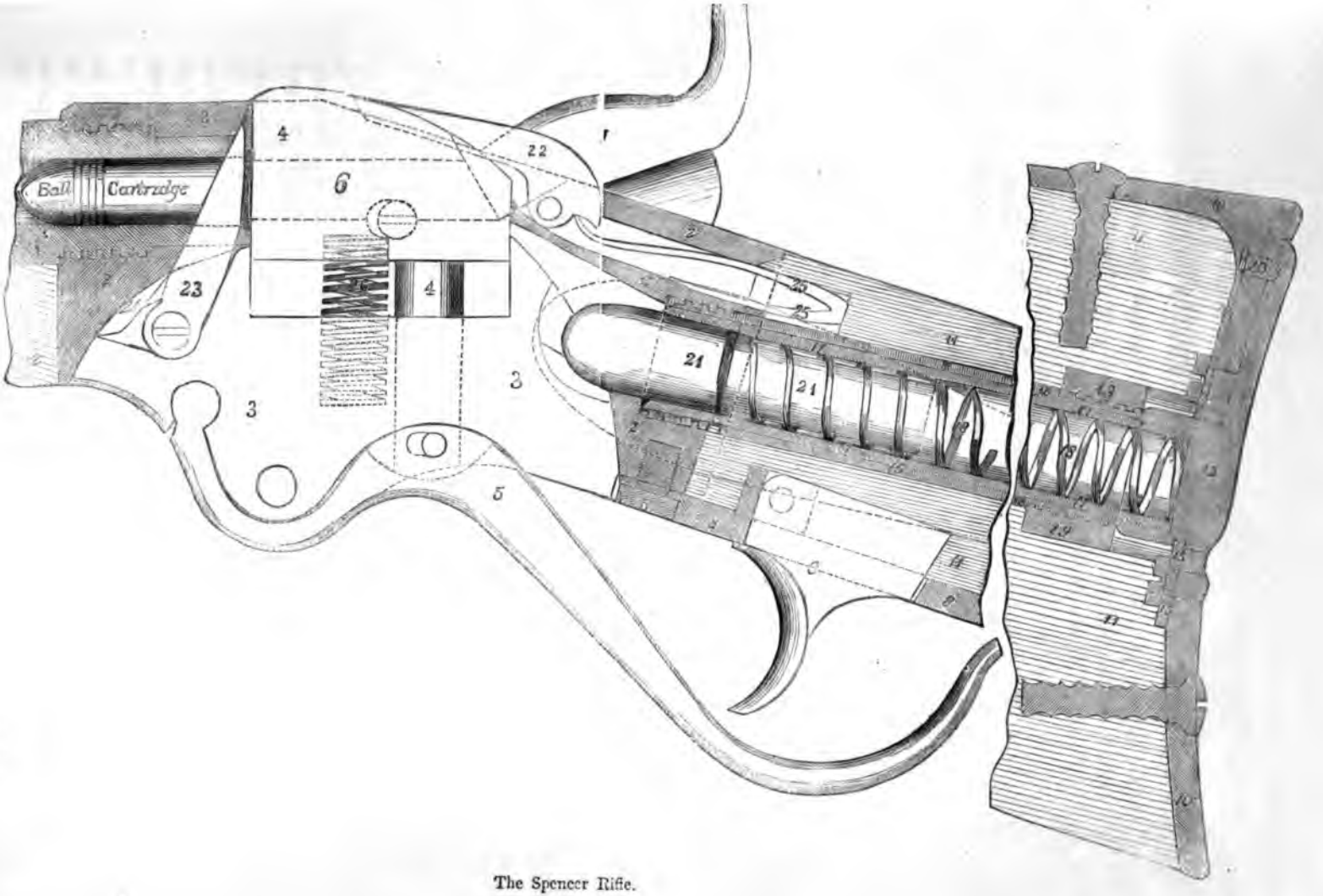
With the muzzle of the rifle pointed downward, turn the magazine-lock (13) to the right, withdraw the inner magazine-tube (17), and drop the cartridges into the outer magazine (16), ball foremost, to the number of seven, then insert the tube, locking it securely in place as first found.

The magazine being thus charged, the first cartridge is thrown forward into the chamber of the barrel, by moving the guard-lever (5) *downward to a stop,* and *immediately* drawing it back. The first part of this movement brings down the breech-pin (4) below the chamber of the barrel, and so that its upper curved profile forms part of the same circle as the back of the carrier block (3). The continuation of the movement of the guard-lever causes both the carrier-block and breech-pin to swing back together far enough for the front cartridge to pass over the breech-pin; and the whole of the cartridges being pressed forward by the magazine-spring (18) and cartridge-follower (21), the front cartridge is made to slip over the breech-pin. When the lever is brought back, the cartridge is pushed forward by the breech-pin into the chamber of the barrel, and the breech-pin is pressed up behind it and is held in place by the breech-pin-spring (26). The magazine and chamber are thus effectually closed by the carrier-block and breech-pin, and all is ready for firing.

The hammer (7) may remain down during the loading, but should be immediately half-cocked, and kept so while a cartridge remains in the chamber of the barrel (1), except when firing. Then full-cock the hammer, pull the trigger (9), causing the hammer to strike the percussion-slide (6), forcing it against the rim of the cartridge, and exploding it.



The Spencer Rifle.



The Spencer Rifle.

The Snider Rifle.

of the cartridge. This cylinder, to admit of expansion by heating, can never be a close fit like the needle-gun; hence the Snider depends entirely, for the prevention of gas escape, on the cartridge. In this respect it resembles the American breech-loaders generally, and therefore the faults that have been ascribed to the weapon by various writers, belong more properly to the cartridge, as witness the accident to Lord Bury.

The woodcut will sufficiently explain the nature of the breech-block, or cylinder. It represents a portion of the rifle showing the end of the barrel D and the breech-block H. Here the breech is shown full open, and at this point, the thumb on the thumb-piece S having turned the breech-block into the right hand, the block, hinged on the pin N by the socket B, is drawn smartly back, when the draw-cartridge ejects the empty cartridge-case. According to the "platoon exercise for long and short breech-loading Snider rifle," "to load the Snider," two movements are necessary, one of which is compound, having several motions under the head of one order, namely, that part of the movement detailed at "Three," of the order "Present," and commencing—"Halfcock — open the breech — and holding the breech-block firmly with the forefinger and thumb by means of the thumb-piece and nipple-lump, draw it back as far as possible by a jerk, raising the muzzle of the rifle slightly in doing so as to remove the empty cartridge-case; at the same time cant the rifle sharply over to the right to allow the case to fall out, bringing it again to the horizontal position; then carry the right hand to the pouch, and take hold of a cartridge at the rim, with the forefinger and thumb." The cartridge is made so as to slide into the breech without pressing, and with as much play at the rim as to allow the breech, block to shut freely. This is absolutely necessary, because the block has no provision for clearing a passage for itself in the event of the cartridge being too tight, or the rim too thick. This loose fit of the cartridge and breech-block, has been animadverted on very severely by the English press, which has rendered great service by keeping before Parliament and the public the defects of the gun, until these defects became fully known. "To know the disease is half the cure;" and so the Snider rifle, or rather the

Boxer cartridge, with the aid of unlimited funds, is creeping slowly out of the difficulty.

The *Mechanics' Magazine* for March last, says that General Peel, then Secretary of State for War, "mentioned Boxer cartridges Nos. 1, 2, and 3 each being of different combinations, for fastening the base to the tube more and more securely. Nos. 1 and 2 have been reported failures. In the meantime millions of these cartridges have been made, at the cost of about £5,000 per million, and cannot be used with safety. If they were given out for service, accidents in the use of the converted Enfield would be frequent and fatal."

The writer is anxious to screen the defects of the cartridge at the expense of the gun, and says, "It is apparent that to cover the radical defects of the Snider system, the cartridge is made to bear the sins of the gun." The truth, however, seems to be, that the gun, hitherto, has been made to bear the sins of the cartridge; for since a better cartridge has been made than those referred to, the performance of the Snider-Enfield has been highly satisfactory. "At the Wimbledon meeting this year," says the *Times* of July 19th,—

"A volunteer, named Andrews, belonging to a Kent corps, and firing with a Snider-Enfield breech-loader at the 500 yards' range, succeeded in firing off no less than 50 shots in the prescribed five minutes—that is to say, exactly 10 a minute. The shots, moreover, instead of being fired off wildly, were delivered with steady aim. In the 50 shots he made 46 hits, of which 10 were bull's-eyes, 20 centres, and 15 outers, equivalent in all to a score of 133. At the very same range, not four hours previously, a competitor had been cheered for making 97, which was then by far the highest score. The astonishing success which had thus been obtained with the Government weapon became known very speedily all over the camp, and the council were actually pressed to confer upon Sergeant Andrews some special mark of recognition. His score, however, was eclipsed by the very last shots fired at the 200 yards' stage of the same competition. In the space of three minutes, allowed at this range, a volunteer, named Oswald, fired 38 shots, or at the rate of nearly 13 a minute, of which 37 were hits. His score consisted of six bull's-eyes, 20 centres, and 11 outers—total, 106."

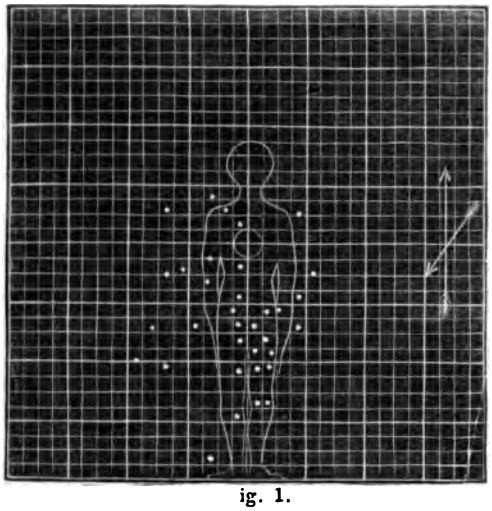
The credit of these high scores is doubtless due, in a great measure, to the marksman's skill; the fact that such scores can be

made with the regulation arm, in so short a time, will go far to acquit the Snider rifle from the charges of inefficiency that have so frequently been brought against it. Besides it must be remembered that the Snider system, as represented in the British gun, has not had the advantages of other systems which begin on a clear foundation; it is merely a converted weapon, and for the purposes of conversion it seems to be well adapted. In the case of the British Enfield, taking everything into consideration, the Snider seems to have made as much of the old materials as could reasonably be expected. Before, however, being adopted for new weapons, it will probably have to compete with a dozen or so of the best, selected from the ninety odd guns tested at the late "Breech-loading rifle competition." On the 25th July the Secretary for War stated in the House of Commons, that, "216,223 rifles had been at present converted on the Snider system, 350,000 would be converted by the end of March next, and they were now going on at the rate of 1,100 per day."

Having referred to the breech-loading rifle competition in Britain, it may, at this stage of our inquiry, be instrumental in furthering the object of this Report to notice, briefly, the several rifles which hitherto have taken a prominent place in the competition, and which will probably be selected for further trials. Before, however, adverting to these English trials, we ought to glance once more at the "Rifle competition at Vienna," already referred to, because the two chief competitors there—Remington and Peabody—both Americans, also attained an advanced position at the shooting-grounds of the Woolwich Arsenal. Indeed, at Vienna the contest was virtually between these two systems, for though the great number of the competing breech-loaders comprised some of the most celebrated European types, they were found decidedly inferior to either the Remington or Peabody rifles. With regard to the tests gone through by the two latter guns, the following, from *Engineering*, is an abstract of the official report, made by the Arch-Duke William, the president of the commission specially appointed for these trials, to the Emperor of Austria.

"The results of the trials made for testing the breech-loading gun on Remington's improved system, were as follows :—

The trials of the Remington gun, marked No. 1, had for their principal object the testing of the breech with regard to its adaptation for military purposes, and with regard to its efficiency and durability under the different circumstances occurring in warfare. The trials commenced on the 20th September, 1866. The gun fired sixty rounds with the heaviest charges present, that is, containing seventy-five grains of English powder; forty rounds with cartridges of sixty grains of powder, against a target 300 yards distant, and forty rounds with sixty grains of powder, fired for rapidity. With these 140 rounds there was no fault of any kind. The breech acted perfectly; the accuracy, as shown by the target [fig. 1], was found very good, and in firing for rapidity, thirteen shots were fired per minute. The gun, having been taken apart after this trial, showed no signs of wear in any part of its breech. It was put together without cleaning of any of its parts, and preserved for further trial.



ig. 1.

Second trial, September 21st, 1866. The firing for testing the durability of the breech was continued with cartridges of sixty grains.

Eighty rounds were fired in one continuous series. One cartridge split lengthways without causing any difficulty in opening the breech, and without covering the latter with dirt. The barrel having then been cooled by cold water poured through it, a further number of thirty rounds were fired, after which cartridges of forty-five grains were used, with which 304 shots were fired. The barrel was cooled after each series of rounds, by running

cold water through it; and at last, after having fired 414 rounds, the whole gun, including the breech, was made wet, and left in that state to ascertain the influence of rust upon the working parts.

Third trial, 22nd September, 1866. The gun, left in a wet state on the previous day, was taken apart and examined. All parts of the breech and lock were thickly coated with rust, but the working of the breech was not interfered with. The gun was put together without cleaning, and the trials continued in that state, in order to establish the influence of rust, covering the breech and lock, upon the firing of the gun.

It was decided to fire 2,000 rounds in all with this gun. Of these, six rounds were fired to measure the force of recoil in a special apparatus. The mean recoil was forty-eight pounds.

Thirty-two round for rapidity, without taking aim, were made by an expert shot in one minute fifty-two seconds, giving seventeen shots per minute. Thirty-four shots were fired in succession, after having covered the whole breech with road dust, and fifty rounds after that, without any difficulty occurring.

The gun was thereupon covered with dust again, and left exposed to the influence of damp air during one night. On the 28th September, 1866, the gun was examined, and it was found impossible to set the hammer at full cock. Having been taken apart, it was found that some sand had lodged itself between the breech-piece and the spring acting upon it, which caused the above-named obstruction. After removal of this sand, but without any further cleaning of the breech, the gun was put together, and its action was again perfect.

The trials were continued. Ten cartridges, which had been previously kept under water for a quarter of an hour, were fired without missing, and eight were fired at a wooden box filled with cartridges. The eighth shot hit the box, and entered through its side. Of the 260 cartridges contained in the box, five were exploded, and the lid of the box thrown off thereby. Of the rest, ten cartridges were squeezed in and spoiled; twenty-six were blackened outside; all the rest remained intact.

After completing the number of 2,000 rounds, seven cartridges, having their ends purposely filed through and cut in different places, were fired, in order to ascertain the effect of the escaping gases upon the breech, in case of bursting of cartridges. The gun was for that purpose inserted in a rest. Five of the cartridges burst open, and an escape of flame was observed at the breech, but the latter was not injured or thrown open.

The final examination of all parts showed no perceptible wear of any of the parts of the breech and lock, the same having retained their original solidity and freedom of movement.

The results of the trials with the breech-loading arm, "System Peabody," were as follows: —

The firing for accuracy in the first series was commenced on the 18th September, 1866, and consisted of

32 shots at a target, distance 300 yards.
30 „ „ „ 600 „

The results obtained are shown in the accompanying diagram of target, fig 2.

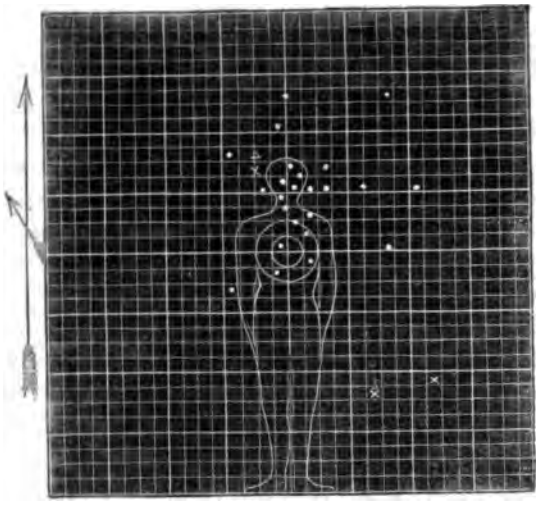


Fig. 2.

With reference to firing for rapidity, trials were made, both aiming from a rest, and from the shoulder without a rest.

In the first manner, fourteen shots in one minute were fired, the cartridges having been placed on a table near the marksman. Of these shots nine bullets struck the target, the latter being eight feet square.

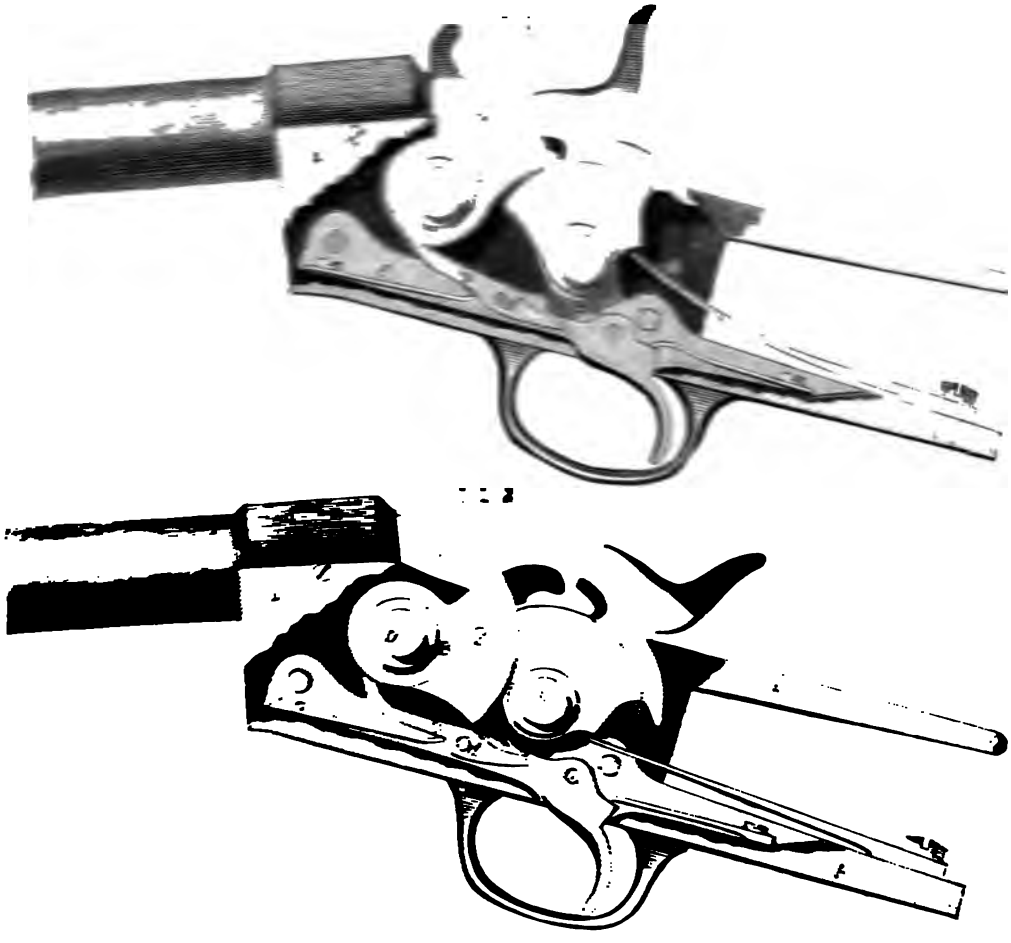
In firing from the shoulder, thirty-two shots were fired in two minutes. The cartridges in this case were also placed on a table.

Besides the 108 shots above referred to, the following were fired from the Peabody gun solely for the purpose of testing the breech.

24 shots in 1 series on the 18th September.
160 „ 5 „ of 32 rounds on 21st September, 1866.
56 „ 1 „ „ „ „ „
150 „ 5 „ „ on 22nd „ „

The firing in the single series was continued without intermission, and the pauses between the series were only long enough to enable the gun to cool. During these 401 rounds, as well as during the 108 before-mentioned, or together 509 rounds, the breech operated perfectly well, and had com-

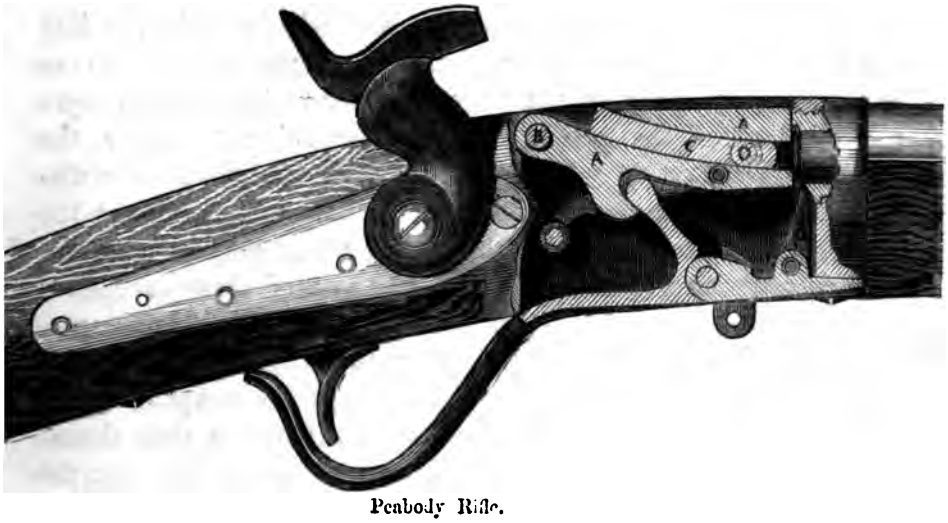
pletely retained its easy movement, although the gun had not been cleaned during the whole course of the trials. In short, no difficulty or objection had presented itself during the various series. The breech apparatus performed its functions with perfect efficiency, only when loading it was necessary to insert the cartridge completely into its chamber, as otherwise the closing of the breech would be impossible, and the cartridge would be liable to be deformed in case the breech-piece should be brought up with a violent motion. Of the 509 shots mentioned, there was one missfire; but this cartridge also exploded after having been slightly turned in its chamber. The cartridge-cases were not injured by firing, and no escape of gas took place. After the fourth day of the trials the gun was taken apart and examined; some rust was found on the barrel, and a deposit from the powder-smoke in some parts of the breech; but the easy movement of the breech apparatus was not in any manner affected. The gun was now cleaned, and firing with cartridges purposely injured was commenced, in order to learn the effect upon the breech consequent on the bursting of a cartridge-case, and the danger to the marksman to be apprehended from the escape of gas. To this end the gun was screwed on a rest, and two shots were fired with cartridges which had been filed and slightly split. The effects of these shots were that the base of the cartridge was almost entirely torn off, the gas escaped upwards, downwards, and rearwards, tore and scorched a paper which had been adjusted over the breech, and about four or five inches from it, and would have seriously injured a marksman. The breech, however, remained without injury, and was covered only with a small deposit of powder-smoke. In measuring the recoil in the measuring apparatus, five rounds showed a mean of 41·6 pounds. During the further trials, a quantity of dirt was thrown into the breech. After each time the breech opened, with somewhat more difficulty than usual, but at the second or third round it recovered its regular easy movement. During the first series on this day, tests were made to prove whether, if the cartridge be inserted while the hammer is down, the cartridge will not explode upon closing the breech. This did not take place. It was also found admissible, and without danger, to fire the gun at exactly the same moment that it was closed. The gun, out of which 1,750 shots had now been fired, was again covered with dirt, and exposed to the damp night air until the following day for continuing trials, namely, on the 22nd of October, 1866. Upon examining the Peabody gun, which had been left in the condition above described, it was found that, although the breech was partially covered with rust, and completely clogged with dirt, it was still capable of performing its functions, though a somewhat greater force was necessary to operate it. Very satisfactory results as to accuracy were obtained. Upon taking the gun apart and examining it, after 1,882 rounds had been fired, no alteration or injury of any part of the breech could be discovered.



Remington Rifle.

Figs. 1 and 2 are longitudinal sections through the breech of the Remington gun. Fig. 1, represents the position of parts after firing; and Fig. 2, when open and ready for loading. The barrel is screwed into the breech-piece, through which pass two strong bolts, *b* and *c*, upon which the breech-block *B*, and the hammer *C*, hinge. In order to remove the empty

cartridge-case out of the chamber, which is in the rear end of the barrel, the hammer must first be locked the breech-block is then drawn backwards, and assumes the position shown in figure 2. By this movement of the breech-block, an extractor, situated in the inside of the chamber, is operated, which draws the cartridge slightly, whereupon it may easily be removed with the fingers. The following cartridge may then be inserted, and the breech-block pushed forward to its original position. To hold it in this position the lever *D*, acting upon the pin *d*, and held in its turn by the spring *e*, is applied, and falls into a notch in the breech-piece. In the breech-block itself, is the pin upon which the hammer strikes for exploding the cartridge, and the hammer is operated by the main-spring, as shown in the woodcut. As the hammer descends, its forward surface, from its peculiar circular construction, collides with the rear surface of the breech-piece, and it also acts as a support in resisting the reaction of the discharge.



Peabody Rifle.

The Peabody gun is represented in section in the above woodcut. *A A* is the breech-block hinged on the pin *B*; *C* is the pin, or striker, which transmits the blow from the hammer to the cartridge, and which is capable of a small sliding motion, determined in amount by the pin passed through the oval hole *O*, shown in

dotted lines. In order to open the breech, the trigger-guard is drawn down, by which the breech-block *A* is depressed, and, catching on the lower part of the elbow-lever *D*, jerks out the empty cartridge-case. By cocking the piece, inserting a fresh cartridge, and pulling up the guard-lever, the gun is again ready for firing.

The result of these Vienna trials was, that the Remington gun was recommended for adoption, but subsequently the blowing open of the breech, or some such accident in the hands of a soldier (perhaps unaccustomed to the weapon), combined with several abortive attempts to manufacture the cartridge in Austria, delayed the execution of the recommendation. At this date, July 31st, it is not known that Austria has decided to adopt any particular system, notwithstanding the various reports to the effect that the "Lindner" rifle has been adopted.*

The "Breech-loading rifle competition" commenced in England on the 24th of April last. The prizes offered were, £,1000 for the best gun, and £600 for the second best, whether adopted into the service or not. Over one hundred competitors put in an appearance, but many excellent weapons, for various reasons, were not eligible for the prizes. It was surprising to notice the numerous instances in which the published conditions were disregarded. Some guns were too short, others too long, some too heavy, some unfinished or improved, and many sent in after the date named for reception. Though any one of these exceptions to the previously arranged terms of the competition would prevent a gun from obtaining a prize, it would not debar it from a fair acknowledgement of the special merits of the weapon.

The regulations adopted were, that two rifles at a time should be shot for accuracy from two shoulder-rests, one on the right, the other on the left of the shooting-stand, with a sufficient space of ground between to admit of the committee freely discussing

* Since the above was written, the Austrian Government, it is said, have adopted the "Wandl" breech-loader, but in the meantime are converting their old guns on the "Wanzl" system. Some Remington rifles have also been ordered.

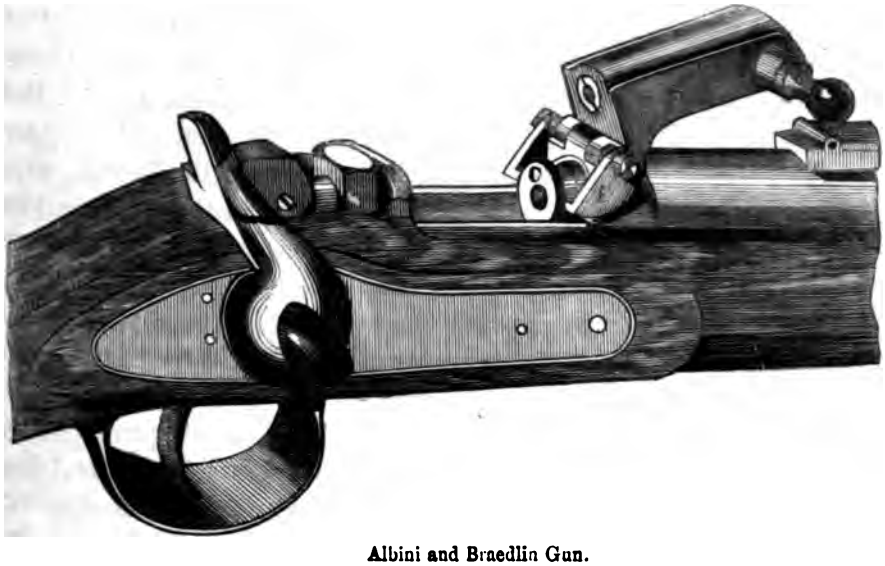
points of merit or information with either inventor, out of hearing of his competitor. These were then fired in succession for rapidity, and after the record of the practice had been made, two other guns were taken in the same manner. Two targets were placed opposite the rests, and the aim taken at either respectively. As the days of trial for particular weapons were fixed, letters of invitation to be present were forwarded to the inventors. The arms selected for the day's trial were placed in the armory, and no one was allowed access, or was permitted to examine any other than his own particular weapon. Among the guns selected for a final competition for the prizes, the following seem to occupy the foremost rank:—The rifle of Major Fosbery, Mr. J. H. Burton, Mr. Henry, and Mr. J. R. Cooper, British inventors; Messrs Albini and Braedlin's rifle on the Mont Storm principle; those of Mr. Joslyn, Mr. Peabody, Mr. Remington, and Col. Berdan, also American, and a gun by Mr. Martini, of Switzerland. In considering the descriptions of the above competing rifles, and their trials, it should be borne in mind that the object of the competition was to obtain data for the selection of the best systems for new weapons for the service, and that the systems best adapted for conversions are not, as already suggested, always the best when a new arm has to be produced. So it is not surprising that the four improved rifles sent to the competition by Col. Roden, on behalf of the Snider Company, have been beaten by other competing systems. But it must be remembered that the Snider system had to comply with the conditions demanded by the War Department, namely, "that the conversion be effected without any alteration of the stock or lock of the existing muzzle-loading Enfield." These conditions have been complied with, but then there is no doubt whatever as to the liability of the Snider breech-blocks to blow open, whenever there is an escape of gas from damaged cartridges, or that the turning over of the piece after each shot to eject the empty cartridge-case, is a clumsy and tiring operation. Hence, it is evident that when a system has to be selected for entirely new weapons, none of these restrictions, incident to conversion, stand in the way of inventors, or the committee appointed to test their guns.

Major Fosbery's rifle is on the Mont Storm principle, which makes six of the ten above-named rifles of American origin. The lock is in the centre of the stock, and the breech-block is designed for central-fire cartridges, but it can be adapted for self-consuming paper cartridges also. The breech-block is hinged in front, and falls over on the barrel. At the side of the breech-arrangement, a slide with a straight projecting handle works horizontally. When this is grasped by the right hand, and drawn towards the body of the shooter, the slide acts upon one side of a sort of semi-circular curve, attached to the breech-block, and automatically turns it over on the barrel. When the cartridge is inserted, the handle is pushed forward, and the block is brought back again into the chamber and closes it. The same slide works an extractor formed by a rod working horizontally on the right side of the barrel. One action thus opening the chamber, and drawing the empty cartridge-case, and another closing the breech after loading.

The explosion-action consists of two pistons, one striking the other in line. One of these secures the breech-block from flying up, on the escape of gas from the chamber. Ammunition; service cartridge No. 1; in firing for rapidity twelve rounds in fifty seconds were disposed of by Major Fosbery.

The gun of Messrs. Albini and Braedlin is also on the Mont Storm system, calibre 0·462 inch, adapted for central-fire cartridge. Breech arrangement put on as a shoe The piston, or striker, passes through the longitudinal axis of the breech-block, and receives the blow of a horizontal bolt worked by the lock. This bolt, in the act of firing, secures the breech-block from being accidentally blown open by any escape of gas. The extractor consists of two simple forks hinged on the pin of the breech-block, a projecting catch on the back of the fork meeting a similar projection on the block, which, in being turned back, acts as a lever to extract the empty cartridge-case. Ammunition; special cartridge, length 3.4in.; weight 689 grains; bullet, cylindro-conoidal, with a basal cavity packed with chopped blotting-paper, weight 480 grains; charge of powder sixty-eight grains. Weight of sixty rounds packed, 61bs. For rapidity, Mr. Braedlin fired twelve rounds in one minute thirty-one seconds. The cartridges

were easily drawn and neither delay nor accident occurred. It



Albini and Braedlin Gun.

will be seen by a reference to the woodcut that the rifle is a combination of the Mont Storm and Snider systems, the arrangement of the extractor being the chief novelty. The breech-block B is here shown open, and the cartridge-extractor E in the act of drawing the empty cartridge C. This gun has been adopted by the Belgian Government, and by all accounts seems to be giving satisfaction. It possesses one or two improvements on the Snider rifle. For instance, if the cartridge does not go home fully, the breech of the Snider cannot be closed, whilst in the case of the "Braedlin" the mere closing of the breech helps to force the cartridge to its place. Again, the axis of the striker is in a line with the axis of the barrel, and thus the cap in the cartridge, being struck more fairly, stands a better chance of ignition, and the protrusion of the exploded cap cannot, of course, prevent the breech from being opened.

Mr. Burton's rifle is adapted for central-fire cartridges; calibre 0·577 inch. The breech-block works on a hinge travelling downward through the stock, by means of the leverage of a short trigger-guard beneath the gun, until it becomes nearly vertical;

the cartridge-case, on extraction, is intended to fall through the slot in the stock to the ground, and if it fail to do so, can be readily thrown out. The extractor is formed to the flat head of a raised band of metal on the circular part of the breech-block over the hinge, and its action is, of course, consonant with the motion of the block in the opening of the chamber. A trigger works a strong catch-plate set in the rear end of the breech, and which, by locking into a corresponding cavity in the stock end of the shoe, prevents any disturbance of the block in the act of firing. Ordinary lock, hammer, and trigger. Ammunition—service cartridge. Mr. Burton fired his twelve rounds in fifty-seven seconds, the most of the empty cases falling through the slot. The breech arrangement worked well.

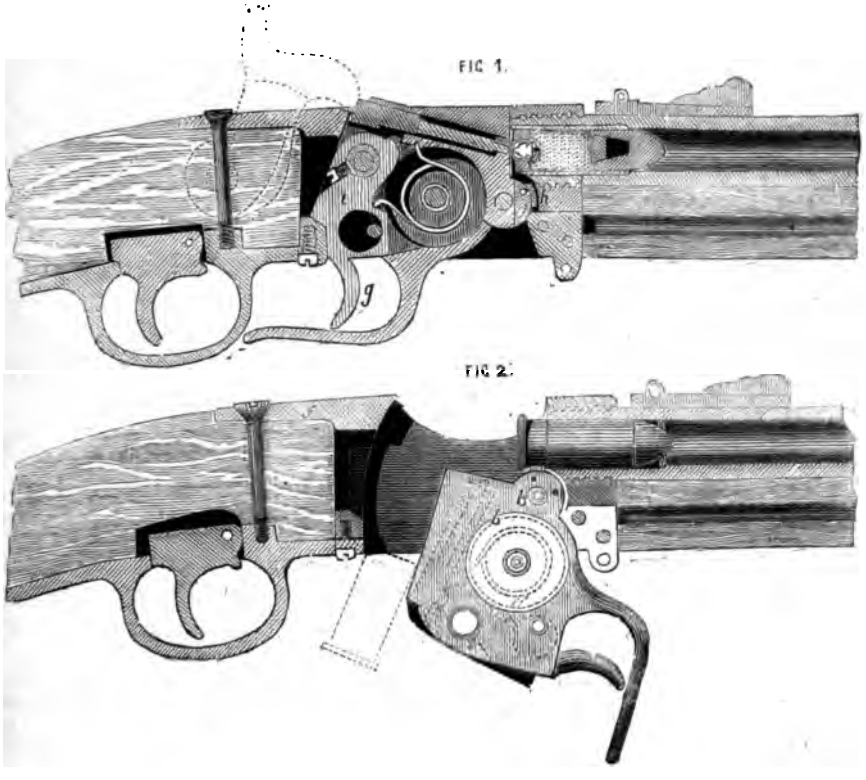
Mr. Burton had a second rifle somewhat similar in principle to the Prussian needle-gun bolt, with piston adapted for central-fire cartridge, calibre 0·577 inch. The bolt slides in the chamber of the shoe in the ordinary manner. On the upper part of the bolt a square block projects, working in a corresponding groove in the inner part of the rear-end metal circle of the shoe. On turning the handle of this bolt sidewise, the end of the projection on the bolt is brought to bear against the face of the chamber-slot in the shoe, and the bolt is fixed in its place.

Rapidity of firing, twelve rounds in one minute two seconds. Service cartridge.

The peculiar arrangement of the Burton gun, No. 1, will be better understood by the following description from *The Engineer*, of London, and the opposite woodcut.

"As may be seen from the drawing, the movable breech-piece is provided at its under side with a handle whereby the breech-piece is moved on its centre *b*, to open, or close, the chamber in the barrel. When closed, it shuts against a fixed projection *i*, in the shoe *f*, and is held in its place by a spring-catch, *j*. This catch is actuated or withdrawn by the lever or second trigger *g*, which forms part of the catch-piece. The actions of opening the catch and drawing down the breech-piece, are evidently included in the one movement. The extractor for removing the empty cartridge-case, consists of a little cam or projection, *h*, on the circular boss of the breech-piece, which, in opening the breech, comes into contact with the rim of the

empty case, and so forces it out, when it drops through the aperture, as shown in the cut. When the new cartridge is inserted, the flange of its base will come against the extracting stud, beyond which it cannot pass until the breech-piece is brought up into its place, which movement will carry the extractor forward, and the face of the breech-piece will then force home the cartridge, simultaneously with the closing operation. The cart-



Burton Gun.

ridge is exploded by means of a striker, somewhat similar in appearance to that in use in the Snider and some other guns, but is really very different. There is no spiral spring to bring back this striker to its normal position, but on the under side of it, and near its rear end, there is a little projecting stud or tooth, which bears against a corresponding one on the upper side of the spring-catch. Should the breech-piece be imperfectly closed, the gun cannot be fired, as the stud on the catch engages the stud on the exploding pin or striker, and prevents it being driven forward by the hammer; while in the act of opening the breech, the stud on the catch pushes back the

striker to its former position, and thus renders the use of a spiral spring unnecessary. The cartridge for this gun may be either rim-fire or central-fire. During the competition the service Boxer cartridge was used."

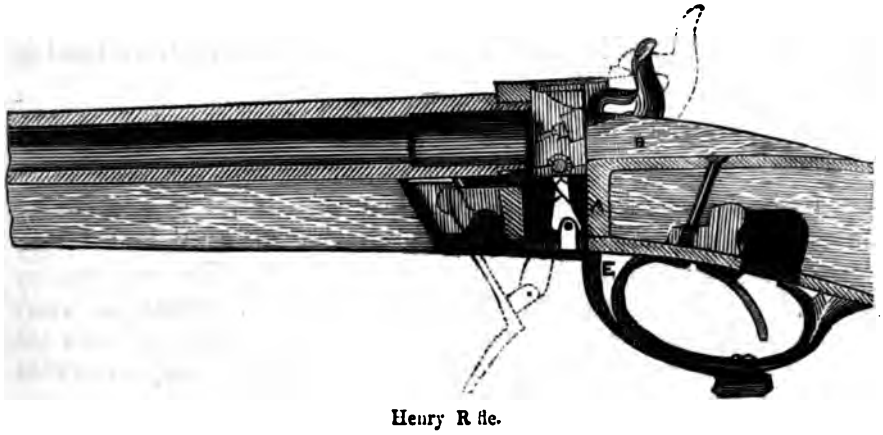
Colonel Berdan's gun, adapted for central-fire cartridges, has a common lock, and a calibre of 0·577 inch. Its other features are a hinged block throwing over to the front; diagonal piston with spiral spring: slight longitudinal motion of block attached to the barrel upon which the breech-block is hinged, to permit, seemingly, of a closer closing home. In the closing, a short-placed cartridge will be pushed, for a distance of half an inch, home into the chamber. The extractor is formed by a doubly-notched oval plate, pivoted on the hinge pin of the breech-block, and the edge of corresponding slot, in which, in the act of the block falling back on the barrel in opening, presses against one notched face, and by a corresponding leverage brings forward the other, and pulls out the cartridge-case; stock not cut away. Ammunition; service cartridge No. 3. Rapidity; twelve rounds in fifty-seven seconds. Breech arrangement worked well.

Mr. Cooper's gun is on the bolt principle, with piston adapted for central-fire cartridges. Calibre 0·463 inch, common lock. Cartridge-case thrown out by drawing back of bolt, the extractor being attached to upper side of bolt. The piston (with a spiral spring) is struck by the hammer, which, at full cock, lies embedded in the centre of stock. Ammunition: service cartridge No. 2. Breech action worked well, and the twelve rounds were fired in one minute two seconds. The Cooper rifle is manufactured and exhibited by the Whitworth Company of Manchester. One of its best features seems to be the arrangement of the lock, by which the bolt is capable of being drawn back over it. The hammer, being in the centre of the stock, strikes the detonating pin a fair blow. The bolt does not, as in the Chassepot, enter the chamber of the gun, or even touch the end of the barrel. It impinges on the iron base of the cartridge, and the barrel (differing in this respect from the Snider) has no recess to receive it (the base), but the projecting rim rests on the end of the barrel, consequently the cartridge is never out of sight, and the soldier sees at a glance if his piece is properly loaded.

Mr. Joslyn's rifle, calibre 0·500, has a swinging breech-piece of a peculiar pattern. This piece swings out laterally at right angles to the barrel, this movement being the chief novelty in the gun's construction. A complete description would be very lengthy; suffice it, therefore, to say, that the cartridge used is the American rim-fire cartridge, bees'-wax lubrication. Weight of sixty rounds packed, 4lb. 14oz. The practice for rapidity at the competition was twelve rounds in forty-seven seconds.

The Henry rifle—the invention of Mr. Henry, of Edinburgh,—is adapted for central-fire cartridges; calibre 0·577 inch. The breech-block is very short, and works vertically in the shoe, being depressed or elevated by a hinged lever, fitting with a catch, over the trigger-guard.

The cartridge is passed into the barrel along an open cutting in the stock, and is exploded by a striker passing diagonally through the breech-piece. The face of the breech-block is fitted with a cavity into which the hammer falls. In the accompanying en-



Henry Rifle.

graving the shoe A, is formed with a long strap, by means of which it is united to the stock; the barrel is screwed into this shoe, but it may be made in one piece. The stock and shoe in rear of the barrel are hollowed out, as shown at B, to admit of the cartridge being passed into the barrel. The breech-piece C, is jointed, by means of a short link, with the lever E, which on being released

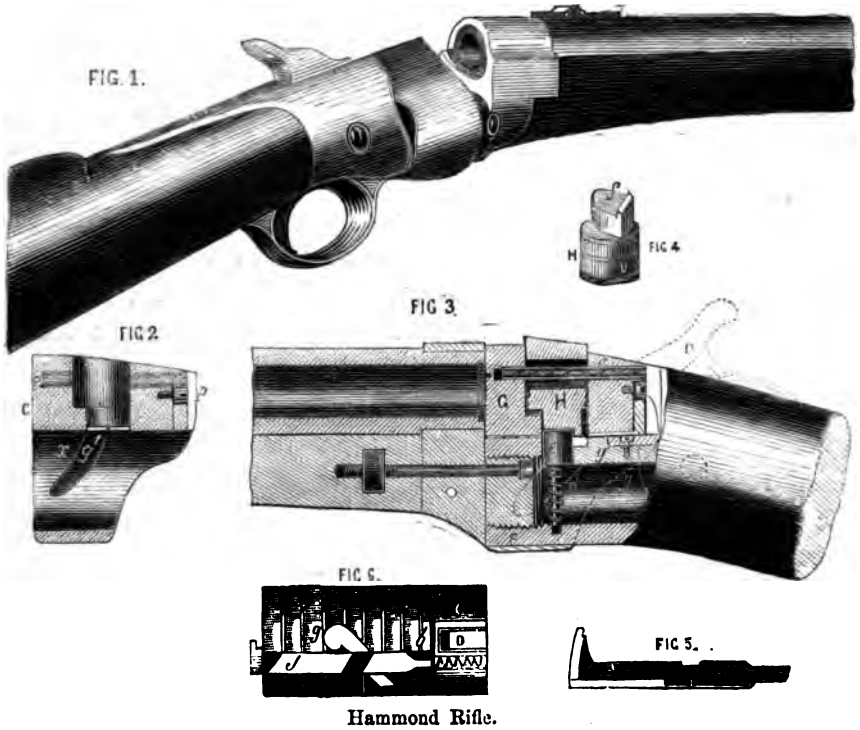
from the trigger-guard and pulled down at the same time, draws the breech-piece into the position shown by the dotted lines in the engraving. At the same time as the breech-piece is drawn down, the inner end of the lever E presses against the extractor and forces it outwards, thus freeing the barrel of the empty cartridge-case. The piston or striker shown in dotted lines in the breech-piece, is driven forward by the hammer, and in order that too severe an impulse may not be imparted to the striker, a portion of the hammer is left projecting at the side, which catches against the side of the breech-piece. The practice for rapidity was twelve shots in forty-nine seconds.

The Hammond gun of the Hammond Connecticut Arm Manufactory, is different in principle from any of its competitors. It was withdrawn to adapt it to central-fire cartridges, and may therefore not be eligible to compete for the prizes. At the trial the ammunition used was the metallic rim-fire cartridge, length 2·24 inches; weight 530 grains. Bullet, cylindro-conoidal, with flattened point, two cannelures, cavity at base, no plug; length 1·46 inch; diameter 0·468 inch, weight 380 grains;—weight of sixty rounds packed, 4lb. 11oz. For rapidity, twelve shots were fired in one minute one second.

The following description and engraving of this gun is from *The Engineer*:—

"In the construction of this gun, that part of the arm or frame forming the sole connection between the barrel and the stock, constitutes a bearing, or journal for the breech-block to turn upon. The rear portion of the breech-block, and that part of the frame against which this rear-portion works, are cam-shaped, or eccentric, and therefore, when the breech-block is swung to the left, it has a lateral and oblique rearward motion in order to open the cartridge chamber, and when swung to the right, it has an oblique forward motion which helps to force the cartridge to its place and close the breech. In combination with, and worked by, the breech-block, is an ejector for removing the empty cartridge-case. On the under side of the breech-block is a projecting piece, which works in an oblique groove made in the arm of the ejector, which is of the ordinary form. When the breech-block is moved in its seat, the projecting piece *f*, shown in fig, 4. by moving in the oblique groove *b*, fig. 6, forces back the ejector, and pushes out the cartridge. The shape of this ejector is seen in

fig. 5. After throwing out the cartridge-case, the ejector is forced back to its position by the spring, fig. 6, and the piece is ready for reloading. The nose and heel of the hammer enter into recesses in the block and frame respectively, so as to aid in strengthening the arm against the strain occasioned by firing. The breech-block and hammer are also serrated at the points where they would touch each other, when the block is swung open, and the hammer accidentally or otherwise let down against it. The object of this improvement is to prevent an accidental discharge, should the breech-block be closed without cocking the hammer, which would let the hammer fly with such violence against the firing pin as possibly to ignite the charge. In the illustration, fig. 3 shows a section



Hammond Rifle.

of the breech-apparatus; H, is the thumb-piece, which, when pressed down, also presses the block *e*, and by turning the breech-block G, to the left, the projection *f* (fig. 4), takes the oblique groove *g*, and the head of the locking bolt takes the groove *ǵ*, fig 2, on, or in the block to admit of it, and causes this block to move obliquely rearward. By continuing the motion of the breech-block, the projection *f*, takes the groove *b*, in the ejector, as above explained. In fig. 3, *c* represents the striker, and D the hammer;

the recess into which the hammer falls is shown at *p*, fig. 2." *The Engineer* adds a foot-note as follows: —"We have since ascertained, that as the pattern gun was not fitted with a cleaning rod, and was some ounces heavier than the regulations prescribed, it was debarred from the competition, but it is nevertheless under trial by the Commission."

The breech-loader of Mr. Martini, of Switzerland, is adapted for rim-fire metallic cartridges; calibre 0·433 inch, breech arrangement as a shoe. The open end of the chamber is closed at the sides, as in the Peabody rifle, the breech-block being also depressed in front in the same manner by the leverage of the movable trigger-guard. If the trigger be pulled while the breech remains open, the trigger-guard and the breech-block fall into place, and the gun is closed up with safety without any explosion of the cartridge. The pulling out of the trigger-guard will then re-cock the piece. The ordinary lock is dispensed with, and the spiral spring within the breech-block drives a piston for striking the cartridge. A detached short piston, working in connection with the lock, acts as a sort of tell-tale, by protruding as a stud when the gun is cocked, and remaining flush when not. The action of this breech arrangement is very attractive. Ammunition-cartridge: length 2·292 inches, weight 520 grains; bullet, cylindro-conoidal, with four cannelures, weight 334 grains; lubrication, white wax, with a quarter part of tallow; charge, 72 grains. Weight of sixty rounds packed, 4lb. 9oz. For accuracy, good; after the eighth round the cartridge-cases drew hard. Rapidity, twelve rounds in forty-eight seconds.

The Peabody rifle used at the trial was 0·500 inch calibre. Ammunition, copper rim-fire cartridge; length 1·91 inch; weight 530 grains; bullet, cylindro-conoidal, with three cannelures and a cavity at the base; length 0·900 inch, diameter 0·52 inch; weight 395 grains; charge 60 grains. Weight of sixty rounds packed, 4lbs. 10¾ozs. In practice for rapidity, twelve rounds were fired in fifty-three seconds.

The Remington rifle was also 0·500 inch calibre. Ammunition, copper cartridge, length 2·22 inches; weight 586 grains. Bullet, cylindro-conoidal, length 0·83, inch; diameter 0·52 inch; weight 407 grains; weight of sixty rounds packed, 5lbs. 2oz.; practice

with central-fire cartridges; for rapidity, twelve rounds in 50 seconds; with rim-fire cartridges, eleven rounds in 40 seconds. In adapting this gun to central-fire cartridges, the breech-block requires to be changed.

Mr. Sharp's rifle also took a good position at these trials, and has some peculiar features worthy of notice, such as the weight of the specified sixty rounds. It is on the breech-block principle, and the calibre is 0·500 inch. The breech action is confined to three parts, the lever, the slide, and the extractor. The lever forming the trigger-guard opens the breech. The breech-slide being spheroidal, permits the use of cartridges with varying thickness of base. Ammunition, rim-fire metallic cartridge; length, 1·89 inch; weight, 552 grains; bullet, cylindro-conoidal, with three cannelures and flattened point, solid base, length 0·83 inch; diameter 0·52 inch; weight 487 grains; wax lubrication; charge of powder 67 grains; weight of sixty rounds packed, 4lbs. 13½ozs.; practice for rapidity, twelve rounds in 51 seconds. Breech arrangement worked well.

The rifle of Mr. Soper, disposed of the twelve rounds in the shortest time — 39 seconds — but it is perhaps too complicated to stand the rough usage of the regular military service. The mechanism of the gun is remarkable for its high degree of elaboration. By one operation the breech is opened, the gun cocked, and the discharged case thrown out. The breech is opened and closed by a wedge-block worked by a hinged lever. The lock is central in the stock, and the trigger, mounted on a lever, can be secured at full-cock by a bolt. Ammunition, similar to service cartridge No 2; length 2·440 inches; weight 765 grains. Bullet, weighs 533 grains; charge of powder, 71 grains. Weight of sixty rounds packed, 6lbs. 10½ozs; practice for rapidity, twelve rounds in 39 seconds; three misfires; accuracy good.

The guns of the Snider Company did not, as already stated, take a prominent place at the competition. Two were large bores 0·577 inch; one was 0·500, and the other 0·450 inch. They were all adapted for central-fire cartridges. There was nothing remarkable in the firing, either for accuracy or rapidity. One of the guns (No. 3) struck the target only thrice in ten rounds. For rapidity the best was the large bore, twelve rounds in one minute

ten seconds, and the worst, the smallest bore, twelve rounds in two minutes three seconds. Some of the cartridges were hard to draw, the base of one broke off and the ramrod had to be used to extract the empty case. These Snider rifles are identical in principle with the converted Enfields before described; the riflings are different, but the chambers are similar. In all these, however, the hammer flies back automatically to half-cock after firing. The weight of sixty rounds packed is, for the large bores, 5lbs. 10½ozs., for the medium 5lbs. 2ozs., and for the small bore, 4lbs. 11ozs.

It is curious to notice that among the competitors at these trials are found many names well-known in connection with fire-arms—old houses and firms—whose guns have been beaten by those of amateur gun-makers, of whom, till this crisis came, the world and the trade knew nothing. The Birmingham Small Arms Company, were represented by the rifle of Mr. Gray, a small bore 0·451 calibre, with a cast-steel barrel. In firing for accuracy, the first cartridge jammed the action, and the ramrod had to be used to clear the gun. For rapidity, the firing was discontinued at the sixth round, the base of the cartridge having torn off, leaving the case jammed in the cylinder.

Messrs. Benson and Co. had four rifles at the trial—three on the bolt system, and one on the breech-block principle, similar to the Mont Storm. The result of the firing with these guns was simply a series of mishaps, not one of the four reaching mediocrity. The Westley Richards Company had four rifles here also, not one of which completed the practice. One only (No. 3) made a respectable show when firing for accuracy, but when firing for rapidity, it became unserviceable at the sixth round.

A Prussian gun, needle principle, furnished by a Mr. Tanner of Silesia, made very wild shooting, and when firing for rapidity the fifth cartridge could not be forced into the chamber, and the soldier's thumb was deeply cut by the sharp edge of the breech in endeavouring to load. The Whitworth Company's rifle was withdrawn, and generally the guns of the best known English makers were not only beaten by outsiders, but by almost all the American guns at the competition. The following table will, at a glance, enable a comparison to be made of some of the results of this

primary competition; for the object of the trials above mentioned was merely to facilitate the selection of a number of weapons for a more thorough competition. From among the names in the table some ten or a dozen will be selected.* The makers will be required to furnish six rifles each (of the pattern of the experimental weapon) and 1,000 rounds of ammunition. For this each maker or inventor will receive £300, and the competition for the two prizes of £1,000 and £600 will then be proceeded with.

* Since writing the above, we learn that the following nine rifles have been selected: Albini and Braedlin, Berdan, Fosbery, Henry, Joslyn, Martini, Peabody, and Remington; one of the makers having two guns representing different systems.

Table of the most Prominent Guns at the Primary Breech-loading Competition in England.

Maker or Inventor.	Nationality.	Principle.	Calibre.	Fulminate.	Charge.	Bullet.	Weight of 60 rounds.	Rapidity 12 rounds in,	REMARKS.
Burton	British	Breechblock	0·577	Central Fire	75 grs.	480 grs.	6lbs. 11oz.	57 sec.	Worked well.
Ditto	Ditto	Bolt, with piston	Ditto	Ditto	Ditto	Ditto	Ditto	1 m. 2 s.	Similar to Prussian Needle Gun.
Braedlin	Ditto	Mont Storm	0·462	Ditto	68 grs.	Ditto	6lbs.	1 m. 31 s.	Worked well.
Berdan	American	Ditto	0·577	Ditto	75 grs.	Ditto	6lbs. 11oz.	57 sec.	Ditto.
Cooper	British	Bolt, with piston	0·463	Ditto	70 grs.	Ditto	6lbs. 2oz.	1 m. 2 s.	Ditto.
Fosbery	Ditto	Mont Storm	0·577	Ditto	75 grs.	Ditto	6lbs. 11oz.	50 s.	Ditto.
Henry	Ditto	Breechblock	Ditto	Ditto	Ditto	Ditto	Ditto	49 s.	Ditto.
Hammond	American	Peculiar	0·466	Rim Fire	Not Known	380 grs.	4lbs. 11oz.	1 m. 1 s.	Ditto.
Joslyn	Ditto	Breechblock	0·500	Ditto	76 grs.	394 grs.	4lbs. 14oz.	47 s.	Ditto.
Martini	Swiss	Ditto	0·433	Ditto	72 grs.	334 grs.	4lbs. 9oz.	48 s.	Ditto.
Peabody	American	Ditto	0·500	Ditto	60 grs.	395 grs.	4lbs. 10¾oz.	53 s.	Ditto.
Remington	Ditto	Ditto	Ditto	Rim or Central	67 grs.	407 grs.	5lbs. 2oz.	50 s. with central fire 44 do. rim fire.	Ditto.
Sharp	Ditto	Ditto	Ditto	Rim Fire	Ditto	487 grs.	4lbs. 13½oz.	51 s.	Cartridge 1·89 in. long.
Soper	British	Ditto	0·570	Central Fire	71 grs.	533 grs.	6lbs. 10½oz.	39 s.	Accuracy, good.

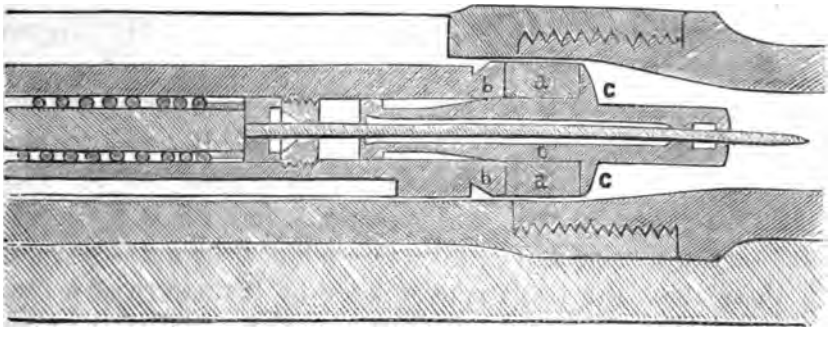
From this table it will be seen that six out of these fourteen competitors are American,* whilst two others are founded on the Mont Storm principle, also an American invention. Of the fourteen guns, eight are for central-fire, and six for rim-fire cartridges. The only case in which the two systems of ignition are fairly compared, is in the Remington rifle, which fires either cartridge, but which made the most rapid shooting with the rim-fire. The gun which carried away the palm in rapidity of fire, was Mr. Soper's, but the delicacy and complication of its mechanism are strong arguments against its adoption as a military arm. The lightest "sixty rounds" is that of Mr. Martini of Switzerland, who also has the heaviest charge of powder in proportion to the weight of the bullet. The average weight of the rim-fire charges and bullets, are to each other as one to six, while the central-fire are nearly as one to seven, hence the former will be able to attain a greater range with a lower trajectory. The average weight of the central-fire sixty rounds is 6lbs. 8½ozs., while the average of the rim-fire is 4lbs. 12½ ozs., consequently, eighty rounds of the latter are no heavier than sixty rounds of the former, a consideration, taken in connection with rapid firing (consequent on the introduction of breech-loaders), and forced marches, of no secondary importance, at least, to the infantry soldier. The average rapidity of the firing with the central-fire-cartridge, as above, is fifty-eight seconds, and one-ninth, and that of the rim-fire fifty seconds, and two-thirds. It is also worthy of notice that besides those in the table, there were sixty-eight central-fire guns at the competition, nearly all of which missed fire frequently, and either wholly failed, or at least did nothing to entitle them to further consideration, whilst no rim-fire gun missed or failed; indeed, all the guns using rim-fire cartridges are in the table. There is, however, something

* While these and similar trials were progressing in England and other countries, several novel and interesting weapons and methods of conversion were being perfected in the United States; among these the Broughton and the Roberts guns—which latter has been adopted by the State of New York—deserve more than a passing notice. See Appendix.

to be said in extenuation of such wholesale failure of the central-fire weapons. The makers or inventors seemed to fancy that their guns would stand a better chance of being adopted, if made to suit the Boxer, or service cartridge, for the manufacture of which an extensive and costly plant of machinery has been got up at Woolwich Arsenal. This may be the reason why most of the competing rifles were designed for central-fire cartridges. The same consideration may probably induce the British Government to adopt some central-fire gun, notwithstanding that the first prize may be won by the other system. The guns, however, which win the prizes at this competition, or may be considered the simplest and best, will still have to compete with the Snider-Enfield.

The CHASSEPOT rifle, the weapon of the French army, is exhibited by Messrs Caen, Lyon and Co. of Paris (who manufacture the gun for the Government) and also by several private gun-makers. It is a needle-gun, differing from the Prussian arm in two particulars. First, the escape of gas is not prevented, as in the Prussian needle-gun, by the perfect mechanical fit of the needle-bolt and the barrel. Second, the fulminate is not in front, but in rear of the charge, and is contained in an ordinary copper cap. The chief feature of the invention, however, consists in the contrivance adopted for preventing the escape of gas breech-wards. The hermetic closing of the breech parts is obtained by the instantaneous compression, under the action of the explosion, of a vulcanised caoutchouc washer interposed between the front face of the breech-bolt and a flange, or shoulder, upon the needle-guide. The needle-guide being moveable, and the front face of the bolt being fixed, the india-rubber washer is nipped between them. The washer and the flange or shoulder are of a little less diameter than the breech in which they are fitted, so as to facilitate their play therein, but the diameter of the front face of the breech-bolt is, as nearly as possible, equal to the inner diameter of the breech. When the explosion takes place, the pressure transmitted by the moveable needle-guide to the washer is such, that the latter is compressed sufficiently to hermetically close the rear end of the barrel and thereby prevent all gas-escape. After the charge is fired, and the pressure removed, the washer, by virtue of its

elasticity, returns to its natural position. The ring or washer is composed of three layers of different degrees of hardness, the two outward layers being of much harder substance than the centre one, so that, on being pressed, the intermediate layer which is perfectly elastic expands. A reference to our woodcut will



The Chassepot Rifle.

sufficiently explain the nature of this breech-closing arrangement. The india-rubber ring *a*, is compressed by the needle-guide C, between the washers *c*, *b*, when the charge is ignited, and is therefore forced to fill the barrel in which, in its normal state, it is a loose fit. This arrangement seems to answer well, and if the copper cap and base of the cartridge can be got rid of effectually after each discharge, the Chassepot (despite the perishable nature of its elastic washer, which, however, can be easily renewed) bids fair to be a more effective and trustworthy weapon than the Prussian needle-gun.*

* Since the above was written the experiments referred to in the following paragraph from the *Illustrated London News* were made in Prussia:—"The Prussian gunmaker Specht has received from Paris a Chassepot gun similar to those adopted by the French army, and experiments have been made with it which, according to the Prussian journals, have furnished important results. The Chassepot is certainly superior to the Prussian needle-gun. Competitive essays have been made with the two. More than fifty officers of all arms witnessed them. The Chassepot was in the hands of M. Specht, the needle-gun in those of one of the best marksmen in the garrison. The

The following particulars relate to the Chassepot rifle—

	French measurement.	English measurement.
Weight	4 kilos. 50 grammes	8lb. 14oz. 13dr.
Calibre	11 m. metres	·433 inch.
Range	1000 metres	1,094 yards.
Weight of cartridge	31 grammes	578.4 grains.
Weight of ball	24 „	370.4 „
Weight of charge	5½ „	84.8 „
Number of grooves		4

No reliable data has yet been obtained for comparing the merits of the Chassepot with other breech-loaders. It was not among the competitors either in England or at Vienna, and the French trials are generally conducted in secret, save when it is considered necessary to give *eclat* to an invention adopted by the Government. In these cases the trials consist more of the nature of a display than experiments. The following account of a trial of the Chassepot rifle, which lately took place before the Emperor and Prince Oscar of Sweden, appeared in the *Times* of the 18th of May:—

"A battalion of the foot chasseurs of the Guard was placed at 600 yards from the mark, and the results obtained were quite extraordinary. After a period of precisely two minutes the trumpet sounded the call to cease firing. It was then found that the battalion (500 strong) had fired 8,000 balls of which 1,992 had struck the line of object aimed at. All the ground immediately in front of the mark was cut up by the balls in such a way as not to show a blade of grass left. The Emperor uttered an exclamation which graphically depicts the result, 'It is frightful! it is a positive massacre!' The battalion afterwards executed several times a similar exercise, but at distances increased to 1,000 yards."

Here the average number of shots per man was sixteen, or at the rate of eight rounds per minute, while the number of hits was nearly twenty-five per cent. which, at 600 yards, may be considered

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arrangement was to fire with each weapon for a minute. The needle-gun was the first; it fired eight rounds and struck the target eight times. The Chassepot fired ten shots and was loaded the eleventh within the minute; it also reached the target eight times. The two guns were afterwards fired together during half a minute; the needle-gun discharged three shots, the Chassepot five. Six of them were found to have struck the target, but from which of the guns was not known."

good shooting. There is, however, something very vague about "the line of object aimed at."

Independent of the great number of Chassepots manfactured for the French Government, Messrs. Caen, Lyon & Co. have lately received an order for 20,000 of these guns from the Government of Japan, and it has also been selected for trial by the Italian, Spanish, and other European Governments that have not as yet adopted any breech-loading system.

M. Devisme, of Paris, exhibits a gun which seems to be a compound of the Chassepot and the Prussian needle-gun. It is a needle-gun, and the breech is closed as in the Prussian gun with a gas-tight metallic joint like a conical valve. The chief novelty is the manner of fixing the breech-bolt. The bolt slides in a groove in the stock, which groove is a continuation of the barrel of the gun. Midway in this groove the bolt passes over a transverse rod or shaft which projects into the bottom of the groove, and is hollowed out to admit of the breech-bolt passing over it. There is a corresponding hollow in the breech-bolt, and when it is pushed home, this hollow is immediately over that of the transverse rod, which has a lever attached to its end, and when this lever is pulled half a turn the round side of the transverse or locking-rod is brought into the hollow of the breech-bolt, and the breech closed. This locking arrangement seems to be very effective, but it necessitates an extra movement—throwing the handle below the barrel, and again towards the handle of the bolt—whereas in the Prussian and Chassepot guns, the breech-bolt is both handle and fastener. We are not aware that Devisme's gun has taken any prominent place in the competitions now going on, though the inventor avers that it can fire fifteen times per minute. It has—in common with the Prussian needle-gun—the advantage of being speedily rendered unserviceable by simply withdrawing the breech-bolt, and the disadvantage of its working parts being too much exposed in wet weather.

Messrs. Jarre & Co., of Paris, exhibit a novel breech-loader, which can be fired, they say, fifty times a minute. It is in some respects a magazine gun, and yet it differs greatly from the American guns of that denomination in the Exhibition, and it has

one advantage over them, namely, that the unfired charges are always in sight; the soldier knows not only when his gun is empty, but how many rounds remain to be fired. The charges—ten in number—are arranged in a sliding breech-block, which moves laterally through a slot in the stock by the action of cocking the gun, so as to bring one charge at a time opposite the barrel as in a "Colt's" revolver. Each cartridge (rim-fire) has a small pin projecting from the flange of its base, and which receives the blow of the hammer, vertically. The charges, to facilitate the loading of the breech-block are (when manufactured) tied together in rows of ten, and are fixed upon a piece of wood by a string. The conical ends of the bullets, which project slightly beyond the piece of wood, are inserted in the breech-block, and a slight pull of the string disengages the ten rounds, and they fall into their places in the block and are locked in by a bar hinged to the block at one end, and locking with a spring at the other; the fresh supply of ten cartridges are then ready for firing. The whole operation of filling the breech-block occupies about ten seconds.

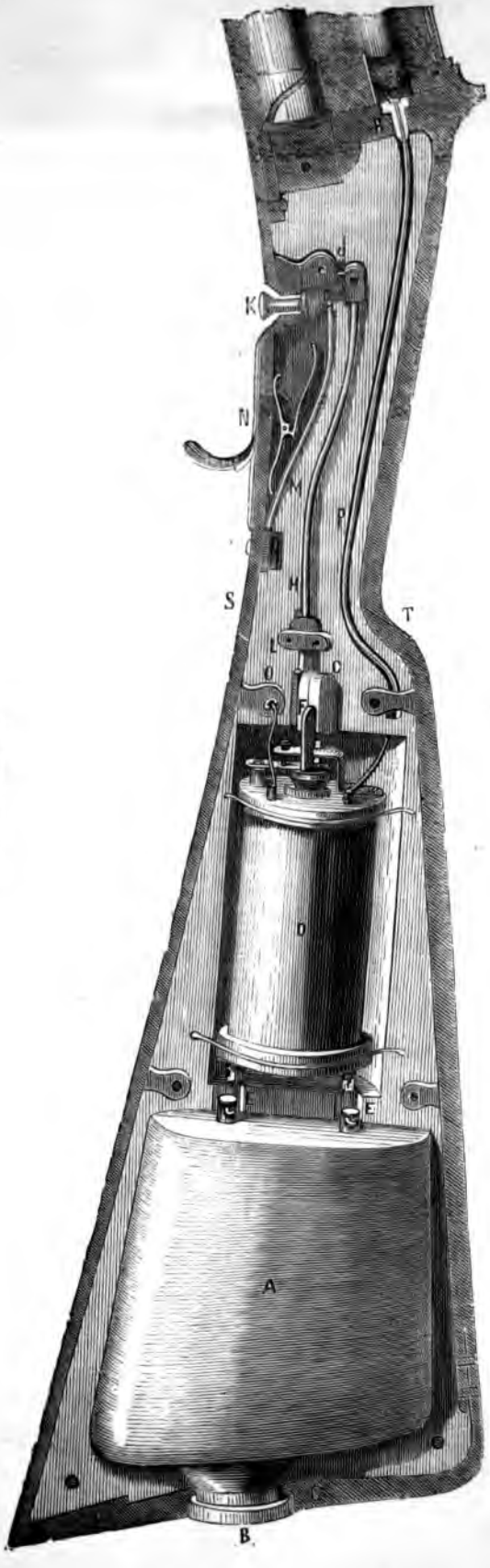
Another gun, in the French Section, worthy of notice, is that of M. Tronchon. It has a breech-block, on the Mont-Storm system, adapted to central-fire cartridges. The breech-block turns over and is secured in position, when closed, by a vertical bolt with a projecting thumb-piece at the side. The piston works horizontally along the axis of the breech-block, the hammer falling on a hinged stud in connection with the fastening-pin, so if the hammer be let fall before the block is bolted in its place, the striker and bolt will be driven by the blow into position together. Ammunition; cartridge with a thick india-rubber wad at the base. India-rubber envelope; an iron pin in the centre of wad conveys the blow of the piston to the fulminate which is put in a card-board *sabot* next the charge. This rifle was at the English competitive trials, but, like the rest of the French and German guns, it took no decided position, and left the contest chiefly between the English and American guns.

A breech-loading rifle to fire by electricity is exhibited in the French Section, by M. le Baron and M. Delmas, of Caen. They say they have been experimenting for a long time on this electric

system, and, after many trials, have at last succeeded in applying it to fancy guns (*fusils de luxe*) and also to military arms. The following is their explanation of the features of the gun and some of its advantages (abridged). All the electric apparatus and the means of applying it, are placed in the interior of the stock, (see woodcut). The cartridge cannot ignite itself by any shock, however violent, as it contains no fulminate nor is there any necessity for caps. The cartridge is hermetically closed at the base, and so has no gas-escape, and therefore the projectile has a greater range. The gun cannot go off without the action of the user (*sans la volonte expresse*), and as it does not require to be cocked, or need any exertion to discharge it, the aim is not disturbed. A is the galvanic pile, which is shut up in the stock by the screw-cover B, this is made to fit closely by an india-rubber washer C ; D is the bobbin; E E the conducting threads and F the magnet. When the pile is in action, the vibration of the interrupter will cause a disagreeable sound. It may also happen that this interrupter is not quick enough in movement, which would prevent the instantaneous ignition of the charge. This inconvenience can be neutralized by the magnet, which, resting on the interrupter, prevents its vibration and puts it in motion when separated. This magnet is inserted in a piece of ivory G, which isolates it from the shank or rod H, and is used to fix it there. The bell-crank J is hinged to the rod, and all is put in motion by a slight pressure of the finger upon the button K. The rod H slides within the stopping-guide L, and separates the magnet from the interrupter, and then only the spark is produced. The spring M, pressing upon the heel of the crank, replaces the button K in its normal position as soon as the pressure of the finger is removed. To prevent accidents, the piece N slides upon the band S so as to cover the button K. This piece is fixed by an interior spring to prevent it from moving accidentally, and this spring has a branch which comes between the button and the heel of the crank to prevent it from acting. O P are the two conducting wires. The latter passes through an insulator R of ivory or hard gutta-percha, and at its extremity is placed a disc of platinum. To give the stock the necessary strength, two bars of brass or steel S T are inlaid

in the stock, and the two sides are held together by screws passing through internal bosses. The cartridge has a base of thin cardboard or linen. The action of the breech is somewhat similar to the Hammond gun, and an ordinary trigger can be used, if deemed expedient. The London *Times*, in speaking of this gun says, "If M. le Baron could simplify and diminish the apparatus it might supersede all hammers, anvils, and caps, but at present it weakens the stock too much." *The Times* might safely have gone a little further, and stipulated for an unfailing certainty of action during thunderstorms and in changeable weather. The breech-loading systems that we have been considering, have already disposed of caps as a separate nuisance, and the American rim-fire cartridge disposes of the anvil, so there remains only the hammer which is more easily carried, and less liable to get out of order than a galvanic battery with its pile, bobbins, conductors and insulators; in short, a complicated mechanical and chemical arrangement, to understand and manage which, every soldier would not only require to be a practical mechanic, but a graduate in chemistry.

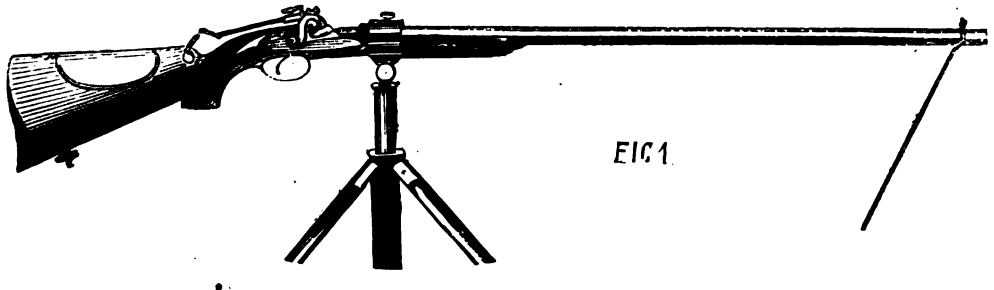
Before finally taking leave of breech-loading small arms, it may be well to say that in the Austrian, Italian, Swiss, and some other sections, there are many guns to which we have not alluded. They are generally crude in design, rough in workmanship, and contain no principle or novelty that would be likely to develop itself into a good breech-loading arrangement. Regarding this class of weapon, it has also been difficult to obtain accurate information; the tendency of inventors, who have taken to a subject with which they are not familiar, being to exaggerate the importance of their inventions. Hence, instead of a simple description of any particular gun, a highly-colored list of its advantages is furnished. Guns of this class abound in the French Section also, the exhibitors of which (following doubtless the example of their Government) are unwilling to give any information, beyond their own views, of the supposed advantages of their weapons. Four Chassepots and eleven other guns of different epochs are among the munitions of war exhibited by the French Government; but in no instance are the cases opened before any stranger without the special permission of the Minister of War, and without such permission, the guardians

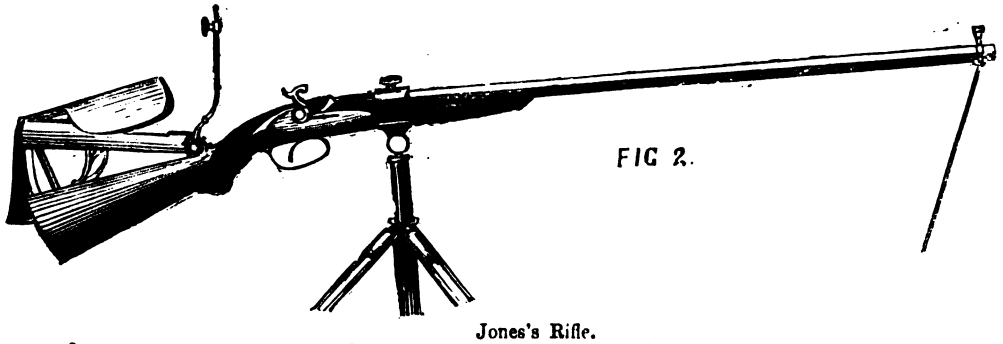


The Electric Gun.

are not even allowed to answer any questions respecting the articles exhibited. The Chassepot, however, is shown frankly, and explained by Messrs. Caen, Lyon, and Co., the contractors, who chiefly supply the gun to the Government. In the British section there are few breech-loaders exhibited. Among these, in addition to those already named, Green's system, exhibited by Messrs Reilly and Co. of London, is perhaps the most promising, though originally devised for a sporting rifle it may easily be adapted for military purposes; it has few movements, and works on the bolt principle by a very simple action.

A real novelty in fire-arms is exhibited in this section by Mr. Jones of Cheltenham, England. It is not, strictly speaking, a military arm, being designed to facilitate firing with accuracy and ease, at long ranges it would chiefly be useful to sharpshooters. The invention is designed to correct the anomaly of shooting at long and short ranges with a stock of the same bend. By a simple mechanical contrivance the rifle can be adjusted from the level barrel to any elevation up to six degrees. The part of the stock bearing on the shoulder is hinged, and moves so as to preserve





Jones's Rifle.

the same position, whatever be the elevation of the gun; the marksman is thus enabled to maintain an easy position under

every diversity of range. Fig. 1 shows the movable stock and sights arranged for firing point-blank, and fig. 2 shows the stock arranged for an elevation of five degrees, at which point the part of the stock which rests on the shoulder has the same relation to the sights as in fig. 1.

In regard to breech-loaders proper, whatever objections may be raised against them, on account of their tendency to waste ammunition, it is plain, that in future wars, they will occupy an important place, and that the nation which neglects to adopt some good breech-loading gun for its armies, will stand on a slippery basis. It is difficult, at this stage of the question, to designate the best weapon, or the best cartridge, nor does the action of the European Governments as yet help to throw much light on the subject.

The French and English only, seem to have adopted some specific system. The first, doubtless, because it is a necessity to be armed with some good weapon now, rather than because the Chassepot is really the best that has been tried. England makes no secret of the fact, that the Snider was not adopted because it was the best breech-loader, but on account of its adaptability to the conversion of the Enfields already on hand. There are rumours and reports that the Swedes and Swiss have adopted the Remington, the Dutch the Snider, Portugal and Italy the Westley Richards, Russia the Berdan, and Turkey, Lawson's ; but it is doubtful if any system, in this age of invention and change, will be fully and finally adopted by any of the leading military powers, at least until the cartridge question is set at rest. The needle-gun, or self-consuming, the central, and rim-fire cartridges are all contending for the supremacy, and each system has its advantages and its disadvantages; to weigh and adjust these, so as to get at the truth, will be a work extending over a long period of time. Meanwhile, the gun which combines simplicity of construction, and a reasonable rapidity of firing, with a good range and a low trajectory, cannot fail to attract attention, whether the charge be ignited by a spark in the centre, or by a ring of fire around its base.

CHAPTER III.

FIELD ORDNANCE.

THERE is considerably less of what is novel and interesting in matters connected with the field-guns displayed at the Exhibition, than in other branches of fire-arms. In has often been observed, that the public can only entertain one idea at a time, and at present that idea, in regard to munitions of war, seems to be, "breech-loading small arms." We by no means aver that there is *nothing* novel in Field Ordnance at the Exhibition, but that the question of arms for infantry has eclipsed, for a time, all other warlike considerations. The "Gatling Battery" and "Ferris' gun" in the American Section, are of themselves sufficient to prove that field ordnance has not come to a stand-still, though the latter gun ought, probably, to be placed among heavier ordnance. The chief question that meets us at the outset of our inquiries, is the manner of loading the gun. Shall it be a muzzle-loader or a breech-loader? The late Austria-Prussian war, especially the battle of Sadowa, has settled this question so far as relates to small-arms. But there is still a great diversity of opinion on this subject in regard to Field, Battery, and Naval Ordnance. Perhaps no abstract question has ever been subjected to such a trying and practical test as this now under consideration, during the celebrated Armstrong and Whitworth trials in England. These trials lasted from January 1863 till August, 1865, and cost for ammunition alone, £33,500 ($167,500).

On entering the Exhibition by the "*Grande Porte*," the first building on the right, opening on the main avenue, is devoted to the British munitions of war exhibited by inventors and private firms, and among these figure conspicuously the rival systems of Whitworth and Armstrong. A twelve-pounder field-piece, similar

to those used at the said trials, is shown by each of these exhibitors. At the trial, however, Sir William Armstrong had two twelve pounders, a breech-loader and a muzzle-loader. The former is not on exhibition. Before proceeding to speak of either of the guns exhibited, we purpose to refer to such features of the competitive trials as bear upon the manner of loading the gun. It being understood that Sir William Armstrong was to furnish both a breech-loader and a muzzle-loader, the Committee received from the War Department the following instructions :—

"*Instructions for the Special Armstrong and Whitworth Committee.*—The Committee are appointed to examine and report upon certain facts, which require to be carefully ascertained before any satisfactory opinion can be pronounced upon the different descriptions of guns and of ammunition proposed by Sir W. Armstrong and by Mr. Whitworth.

It is intended that the inquiry should embrace the fitness of the guns and ammunition for the various purposes to which ordnance may be applied, namely :—*For Land Service.* 1. Field-guns. 2. Garrison-guns. 3. Siege-guns. 4. Heavy guns for coast defences. *For Sea-Service.* 1. Broadside-guns. 2. Pivot-guns. 3. Boat-guns. 4. Guns for cupolas. *Applicable to both Services.* 1. Guns for use against iron plates.

The Committee, in considering the fitness of the guns for the several purposes above named, should report upon the comparative qualities of the different guns and ammunition under the separate heads of—Range, Initial, velocity and retardation, Accuracy, Penetration, Ease of working, Recoil, Rapidity of firing, Capacity for firing different kinds of projectiles, Apparent capability of standing the rough usage of actual service, so far as can be ascertained, from—Endurance, Capability of bearing continued firing, with the maximum charge adapted to the gun, Simplicity of construction, Facility of repair, and Comparative cost, so far as can be ascertained, before the manufacture has been systematically established.

The Committee will report upon the suitableness of these guns for Muzzle-loading, and Breech-loading.

As the Committee may not have an opportunity of comparing guns of the same weight, they will carefully note the comparative weight of all guns examined, and also, their calibre; their material; their construction; their system of manufacture; and they will state any facts on these points which experiment may enable them to ascertain.

In considering the projectiles, fuses, and ammunition proposed, the Committee should include in their inquiry—*For Field Guns.* 1. Solid Shot. 2. Segment (or Shrapnel) Shells, with Concussion and Time Fuses

and bursters. *For Garrison and Siege Guns, and Guns of Position, and for Guns for Sea Service.* 1. Solid Shot. 2. Segment (or Shrapnel) Shells with Concussion and Time Fuzes or bursters. 3. Common Shells with Percussion Fuses. *For Use against Iron Plates.* 1. Solid Shot. 2. Shells and Fuses.

They should give their attention to the various purposes for which projectiles would be required to be used with each class of gun—such as against troops at long or short ranges; against earthworks, masonry, or iron defences; against wooden, iron, or iron-plated ships, either from other vessels or from fixed batteries; for ricochet fire, penetration under water, &c. They should not overlook the applicability of the guns submitted to them to employment with special projectiles, such as shells filled with molten iron, &c. They should report on the material and shape of the various projectiles for the different purposes required. They should also satisfy themselves as to the fitness of the various projectiles and their parts to bear carriage, whether in limbers, ammunition waggons, or on board ship; their liability to deteriorate by damp, immersion in water, hot climates, &c.; their simplicity of construction; freedom from liability to injury by rough usage; and comparative cost, so far as can be ascertained, before the manufacture has been systematically established.

In considering guns and projectiles intended for use against iron plates, they should have regard to their penetration, both when fired obliquely and at right angles to the target; to their smashing effect, as well as to their destructive power after passing through the plate. On these points the results obtained by the inquiries of the Iron Plate Committee should be fully examined.

As a great number of experiments have been made of late years with the guns and projectiles proposed both by Sir W. Armstrong and by Mr. Whitworth, the Committee should examine the officers who have conducted them, as well as those who have had experience of the use of any of the guns brought under their notice with troops, either in the field, or in time of peace, or on board ship. They need not repeat experiments of which the results have been already ascertained by competent witnesses, but will direct their special attention to elucidate such points as may appear to them to require further examination.

To guide the Committee in this inquiry, all the information in the possession of the War Office, the Horse Guards, and the Admiralty will be placed at their disposal; and they will make application to the War Office before incurring expenditure for such experiments as may be deemed necessary.

The Committee should report from time to time, so soon as the facts under any one head of their inquiry shall have been ascertained."

Colonel Miller, R.A., lately read a paper before the Royal Artillery Institution at Woolwich, on "The comparative advantages of Breech-loading and Muzzle-loading systems for Rifled Field Artillery." Col. Miller was Secretary of a committee of Artillery officers, which was appointed last year to report upon this question of breech and muzzle-loading field-guns. This committee made the Armstrong and Whitworth experiments the basis of their inquiry. Now the primary committee—the Armstrong and Whitworth—had gone very exhaustively into the question. They examined twenty-seven witnesses experienced in the manufacture or use of artillery, whose evidence embraced 4,132 questions and answers. They carried out, during twenty-one months, a series of trials which seemed to test every phase of the question, and in regard to the relative merits of the different systems of loading, they found as follows:—

"That the breech-loading gun is far inferior as regards simplicity of construction to either of the muzzle-loading guns, and cannot be compared to them in this important respect in efficiency for active service;" and again, "That both Sir W. Armstrong's and Mr. Whitworth's muzzle-loading systems, including guns and ammunition, are on the whole very far superior to Sir W. Armstrong's breech-loading system for the service of artillery in the field."

Colonel Miller classifies the practical tests to which the guns and ammunition were submitted as follows:—

A. *Shooting qualities*—as to (1) range; (2) initial, velocity and retardation; (3) accuracy.

B. *Practical effect in the field* against—(4) earthen field-works; (5) walls; (6) stockades; (7) field artillery; (8) targets representing bodies of troops.

C. *Service of the guns*—(9) ease of working; (10) rates of firing; (11) extent of recoil; (12) boat-service.

D. *Hard usage and rough work*—(13) endurance; (14) strength; (15) power of withstanding effect of a shell bursting inside the bore, and (16) of a shell striking the outside; (17) capability of being brought into use after being upset.

E. *Durability of the ammunition*—(18) under travelling; and (19) under exposure to wet.

The results of the contest, as between the Armstrong muzzle-loader and the Armstrong breech-loader, and exclusive of the Whitworth, are expressed in the following table, in which the gun that answered best is shown by the figure 1, and equality is denoted by the sign =.

Trial.		Breech loaders	Muzzle loaders	Remarks.
(1) Range	shot		1	Mean errors ... 19.3 and 18.8
	segment shell	1		,, 5.92 ,, 6·82
(2) Initial velocity	shot		1	Mean velocities 1246 ,, 1356
	segment		1	,, 1248 ,, 1356
	shell		1	,, 1238 ,, 1358
Retardation ...	shot	1		Retardations ... 190 ,, 247
	segment	1		,, 189 ,, 247
	shell	1		,, 184 ,, 238
(3) Accuracy ...	shot		1	
	segment shell	1	1	
	shell	=	=	Under ordinary circumstances.
(4-8) Effect in the field.....		=	=	By special arrangements.
(9-10) Ease of working and rate of firing		1	1	Without lubrication.
(13-17) Hard usage, &c.....		=	=	
(18-19) Durability of ammunition...			1	

Thus the balance of advantages lay on the side of the muzzle-loader, some other advantages that could not be tested at these trials have been claimed for the breech-loader, the chief of which is, "that by carrying off the breech-piece the gun is rendered useless to an enemy." But advantages that are suggestive of defeat seldom receive much attention. On the other hand, Col. Miller enumerates no less than ten disadvantages inherent in Sir William Armstrong's breech-loader as compared with his muzzle-loading gun, viz., the liability of the breech-action to become unfit for use by the fracture of the vent-piece, by jamming from rust, grit, or accidental injury, or by the gas-check becoming imperfect from any of these causes; the liability, in the hurry of action, to accidents due to the non-screwing up of the breech; the number of separate parts and the delicate adjustment required entailing the occasional employment of skilled artificers; the projection and consequent liability to injury of some of the parts; the necessity for the employment of detonating arrangements to ignite the time fuses; the difficulty of instructing gunners thoroughly in the mode of action of those fuses; the liability of the lead-coating to strip, if not very carefully secured in the first instance; the liability of the same coating to injury, to an extent which may possibly interfere with loading; the absolute necessity for the employment of lubricators.

The following, from the report of the Armstrong and Whitworth Committee, will still further explain and illustrate some of these disadvantages :—

"Having thus described the construction of the several guns, the Committee have to report that, considering the number of spare articles which must be carried with each breech-loading gun to ensure its efficiency, and the number, weight, aud cost of special tools and implements, and the complication in the store department consequent on their issue and maintenance with field-batteries under all conditions of service; and considering also the necessity there is that men skilled in the use of these implements should always be present with each battery to use them and keep the guns in efficient repair, they are of opinion that this gun is far inferior, as regards simplicity of construction, to either of the muzzle-loading guns, and cannot be compared to them in this important respect in efficiency for active service."

The Committee further add:—

"As regards the breech-loading arrangements, the Committee have been informed that the copper rings of the vent-pieces and bouches of the guns require refacing and renewal, after a certain number of rounds, dependent on the care and attention with which the action of the powder is observed. For this purpose complicated and costly tools, which are different for every description of gun, and require a certain amount of skill in manipulation, have to be issued and always carried on service with the guns; spare vent-pieces and copper rings have also to be carried.

The Committee have received evidence of frequent accidents having occurred with guns of all sizes from vent-pieces having been blown out in some cases, and broken in others, both on service and at practice on land as well as at sea, and as a consequence the whole of the vent-pieces in the service had been recently exchanged, a new construction of vent-piece having been approved. This vent-piece, which had not yet been generally introduced into the service, is intended to prevent a recurrence of these accidents.

The Committee desire to refer to the evidence relative to those accidents which have occurred on active service in presence of an enemy.

Major Milward, Royal Artillery, reports a vent-piece having been blown out of a field-gun during the China war in 1860, through the carelessness of the man who was trusted to screw it up; by this accident the traversing apparatus on the gun-carriage was rendered unserviceable, but it "did not in any way affect the use of the gun."

Colonel Barry, Royal Artillery, also reports that a vent-piece was blown out in China.

Captain Seymour, C.B., Royal Navy, reports a vent-piece having been blown out of a 12-pounder field-piece in an expedition against some of the natives of the Fiji islands in 1861, by which the English Consul was badly burnt, the officer in charge of the boat and six men were wounded, one of them seriously."

Two similar accidents were reported to have occurred with the guns of the Royal Artillery in New Zealand.

It appears also from the reports of her Majesty's ships engaged at Kagosima, Japan, on the 15th and 16th August, 1863, that with the eight 110-pounder guns which were engaged, and fired altogether 168 rounds, one vent-piece was broken, and complaints were made of the vent-piece jamming, and of great difficulty being experienced in firing one gun, in consequence of the rain wetting the vent-piece and running into the chamber. On the same occasion 187 rounds in all were fired from the thirteen 40-pounders engaged, in the course of which one iron and four steel vent-pieces were cracked, one steel vent-piece was broken, and two vent-pieces were blown out.

These reports, which are the recorded evidence of a very limited use of the breech-loading Armstrong gun with old pattern vent-pieces on active service, may be considered as indicative only of what might be expected in more serious affairs, such as a general action or decisive battle, in which a numerous artillery would be employed; combined with other evidence they tend to show that the vent-piece is an element of insecurity which has been found objectionable even at practice, and may therefore be expected to be much more so in the hurry and excitement of action."

It must, however, be borne in mind, that the above objections apply specially to the Armstrong breech-loader, and not to breech-loaders generally, though some of the faults of this gun will doubtless apply to other breech-loading systems, as almost all of them require some finishing tightening touch likely to be forgotten in the heat of action. Notwithstanding the conclusive nature of these trials and reports against the Armstrong breech-loader, this gun is still the field-gun of the British Army. The Breech-loading Committee, of which Col. Miller was secretary, consisted of a lieutenant-general, five major-generals, a brigadier-general and six colonels of Artillery. These officers represented the present state of Field Ordnance, referring to the Armstrong breech-loader, as "anything but satisfactory and unanimously recommended that the system should be changed to muzzle-loaders the first opportunity." Col. Miller's paper, from which these particulars have been drawn, concludes:—

"If we had to take immediate part in a European war, we should bring into the field a delicate gun requiring constant care and a great variety of stores for its sole use; we should further be liable to the risk of the gun failing us at critical moments; but we should not have the satisfaction of getting any advantage in range, accuracy, or rate of fire which would not equally be presented by a muzzle-loading system."

The breech-loader being thus disposed of, the contest in these trials was really between the two muzzle-loading guns, the particulars of which are gone into at great length in the "Report of the Armstrong and Whitworth Committee." A few facts respecting the several points tested may be interesting. First, however, let us ascertain what the rival guns were. The report says:—

"As to construction, Sir W. Armstrong in his evidence stated that "the whole of his guns are upon what he calls the coil system, which consists in forming tubes by rolling up iron bars in spiral coils, and then welding them longitudinally; and when a continuous tube is necessary, joining them up in the end direction. Repeated layers of these tubes are shrunk on in succession, at high temperatures, until the necessary thickness of metal is made up. He stated that the first gun he constructed was made with a steel barrel, the other parts all being coiled, and that he still continued to prefer that plan, assuming it to be practicable to get a material that can be depended upon, but that in all attempts he had made he had met with such disappointment in the use of steel, and so much uncertainty, that he had been obliged to abandon it, and confine himself to wrought iron; he added, however, that so much progress was being made in the manufacture of steel, and that he himself had lately been led to such improved methods of treating it, that he fully expected the time was not very distant when the original idea of using steel for the barrel would be revived, and coil guns made with an internal tube of steel. His reasons for desiring to use steel instead of coiled tubes for the barrels were, that steel is a more close, a more compact, and a more perfect material, that it is harder, and of greater durability, and that by its use defective welds would be avoided. The difficulties in making the inner tubes perfect and sound when coiled had been very great; these would be avoided if the tubes were made of steel, the employment of which he considered more important in large than in small guns."

Mr. Whitworth in his proposals disclaimed the intention of proposing any particular gun for the acceptance of the Government; but submitted for selection, in the experiments to be made by the committee, a list of rifled guns which were being manufactured

by his firm. Mr. Whitworth's system of rifling may be described in general terms as an hexagonal bore with a rapid twist, although, strictly speaking, the bore is not hexagonal, but has twenty-four surfaces. The gun is in the first instance bored out cylindrically; a part of this original bore is left in the centre of each side of the hexagon, making six surfaces. Then there are the coming-out sides of the hexagon, which give six more surfaces, and the going-in sides also six surfaces, and lastly, the rounding off of the angles, which give six more, making twenty-four surfaces in all.

The following table gives the particulars of the two twelve-pounder muzzle-loading guns:—

	Armstrong.	Whitworth.
Weight of gun ..... cwts.	8·93	10·21
Calibre ..... inches	3·0	{ 3·02 { 2·14
Length of bore ..... „	67·74	74·0
„ „ ..... calibres	22·56	{24·5 {27·1
Length of gun ..... „	23·91	{26·49 {29·3
„ „ ..... inches	71·75	80·0
Rifling, one turn in ..... calibres	35·0	{18·21 {20·14
„ „ ..... inches	105·0	55·0
Charge ..... lbs.	1·75	1·75
Shot, weight ..... „	11.56	{11·9
„ length ..... calibres	2·54	{2·89 {3·2
„ „ ..... inches	7·62	8·75
Segment or Shrapnel Shell :—		
Weight ..... lbs.	11·5	11·93
Length ..... calibres	2·42	{ 2·96 { 3·28
„ ..... inches	7·26	9·96
Bursting charge	1 oz.	6 or 12 drs.
Common Shell :—		
Weight ..... lbs.	11·19	11·78
Length ..... calibres	3·0	{ 3·58 { 3·97
„ ..... inches	9·0	10·84
Bursting charge ..... oz.	9·5	8·5
Windage of shot ..... inches	0·05	0·04
„ shell ..... „	0·05	0·04

Note.—The two numbers given under the head of calibre in the Whitworth gun have reference to the diameters of the circumscribing and inscribing circles.

The Whitworth gun is 20 per cent. heavier than the Armstrong, and the twist of the rifling is nearly twice as rapid. The charge of both guns at the competition was the same. In regard to range the two guns were equal when level, and at one degree elevation; but from 3 to 33 degrees, the Whitworth was from 2 to 29 per cent superior. After firing 2,800 rounds each, the Whitworth fell off, at five degrees elevation, from 2,330 yards to 2,211 yards, and the Armstrong from 2,230 to 1,925 yards, the former being 5 per cent., and the latter 14 per cent., lost in range, which the committee considered was the result of scoring, and the consequent escape of gas by the enlargement of the bore. In firing Segment or Shrapnel shell point-blank, the Armstrong was five and a half per cent. superior to the Whitworth, and the latter, at 5 to 10 degrees elevation, was two and a half per cent. superior to the former. In regard to "Accuracy," the committee find that "the advantage of the Whitworth gun in respect of accuracy with solid shot, as compared with the breech-loading Armstrong gun, is very marked throughout. The accuracy of the Whitworth gun with solid shot is greater than that of the muzzle-loading Armstrong gun in most cases, this is so in a very marked degree at ranges beyond 3,000 yards."

In respect to "Ease of working," the two guns were about equal. They were mounted on compressor-carriages in the bows of pinnaces, and ten rounds were fired from each, the boats having slight, but rapid, rolling, and pitching and yawing motions. The average time of each round was 90 seconds. The report goes on to say:—

"The competitive guns were afterwards thrown overboard from the boats, dragged ashore through the water, sand, and shingle, mounted, limbered up, and dragged a few yards, and then brought into action and a round fired from each.

"The following are the periods recorded against each gun for the whole operation, after deducting what was due to the mounting of the carriages and limbers.

	Min.	Sec.
Breech-loading Armstrong . . .	3	30
Whitworth	5	54
Muzzle-loading Armstrong . . .	5	23

"The difference in time is fairly due to the difference in the weight and handiness of the guns.

"The committee had found that the Armstrong muzzle-loading gun could be fired continuously without, or with only partial, lubrication; and as they considered that contingencies might very possibly occur on active service which would prevent the employment of lubrication, the supply and transport of which must always cause an additional complication, and that therefore that gun would have a decided advantage for service in the field which should be capable of being fired with ease continuously without lubrication, it was determined to try the experiment of firing a number of rounds with only powder and shot. The Whitworth gun fired eighty-six rounds in thirty-four minutes and a half. The muzzle-loading Armstrong gun fired the same number of rounds in twenty-eight minutes; both made excellent practice; but the committee did not complete the practice with the breech-loading Armstrong gun, as it became evident, from the stripping of the lead from the projectile, that this gun could not be used continuously without lubricators or water. The breech-loading apparatus also jammed, owing probably to the air space left by the abstraction of the lubricator."

As to "Endurance," the committee say:—

"It would appear therefore that though Mr. Whitworth's gun possessed greater endurance, it possessed the disadvantage, as compared with Sir William Armstrong's guns, of not giving indications, such as could have been observed on service, of the approaching destruction of the gun. The committee, however, desire to observe that these experiments exhibit a degree of strength, in all the guns, which far surpasses the possible requirements of the service."

Referring to "Simplicity of construction," the report says:—

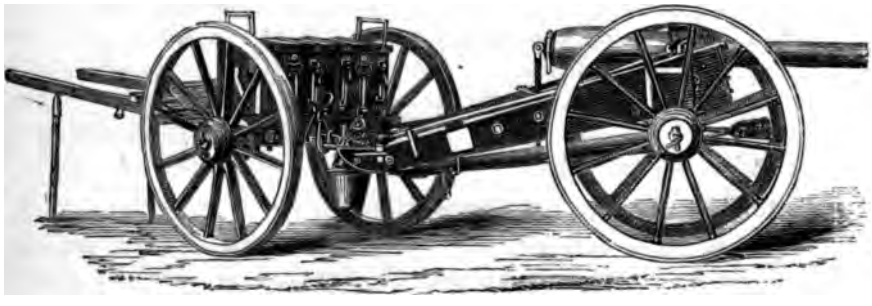
"With respect to the two muzzle-loading guns, they have to report that there is no very material difference as regards simplicity of construction with guns not exceeding in calibre the twelve-pounders; the Whitworth gun, however, is manufactured of one material (except the trunnion-ring), and has a like section of bore throughout; whereas the Armstrong muzzle-loader is made of two materials, has a special powder-chamber, and, besides the shunt arrangement, the grooves have inclines towards the muzzle, which make the section of the bore vary."

Regarding the cost of these twelve-pounder field-pieces—about £220 ($1,100) each, the committee say:—

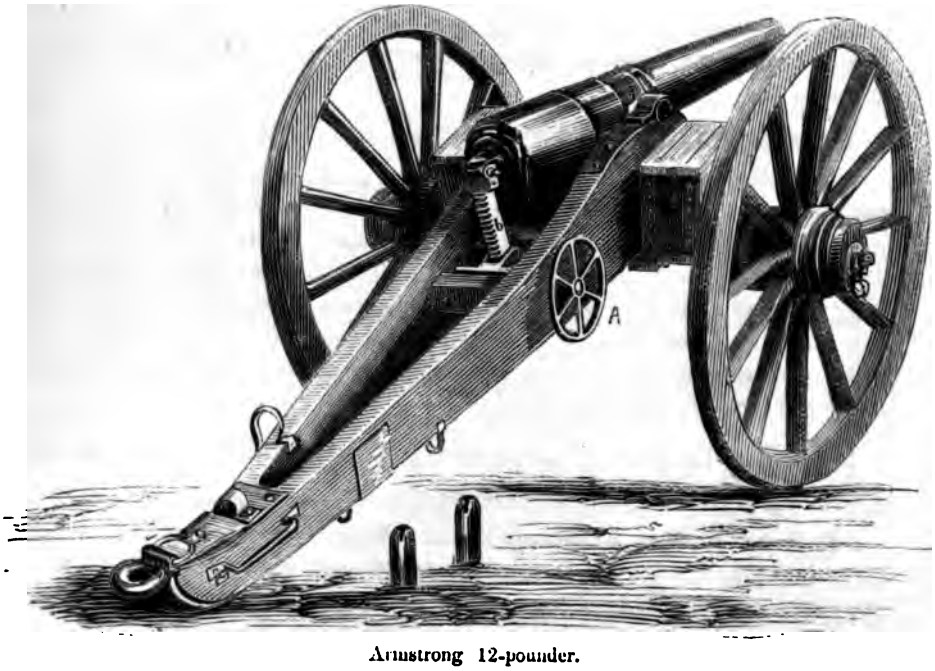
"Both Sir William Armstrong and Mr. Whitworth object to these prices being taken as fair criteria from which to judge of what the cost of their respective guns would be if the manufacture were fully established to meet a large demand; in this opinion the committee quite concur.

From the description given under the head of "Simplicity of construction," it will be evident that the two muzzle-loading guns are much about on a par with each other in respect of the processes they have to undergo in their manufacture; if anything, there is rather less work on the Whitworth, which probably is compensated by its being a hundredweight heavier, and having more steel in it, so that these two guns, if made in the same factory, and under like conditions, would be supplied at costs which, for all practical purposes, may be considered equal."

To describe the projectiles used at these trials and go, even partially, into the details of the firing would absorb the time and



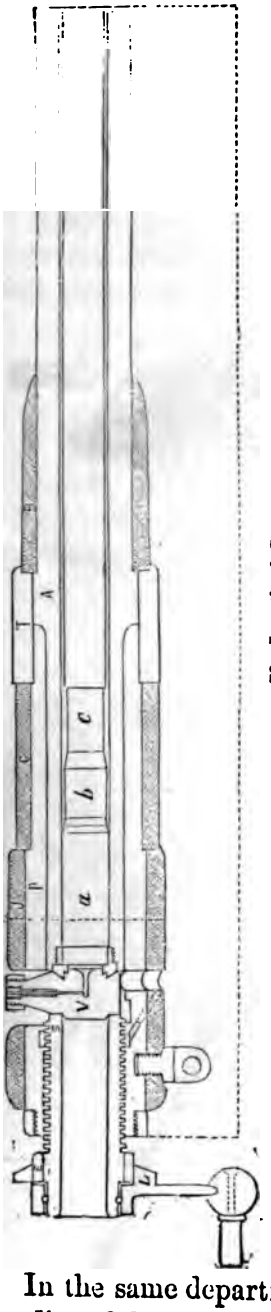
Whitworth 12-pounder



Armstrong 12-pounder.

space necessary to do justice to other and equally-deserving guns,

A twelve-pounder field-piece similar to those tested at these trials is exhibited by each of the inventors. These guns are represented, mounted, in the previous woodcuts. The Armstrong gun *exhibited* is, however, mounted on an *iron* carriage, with iron wheels, the spokes of which can be removed at pleasure. The elevation of this gun is regulated by the wheel and rack A, b, which system is now generally adopted in the British naval gun-carriage.



A breech-loading Armstrong field-piece of the same calibre is exhibited by the British Government alongside of the Woolwich guns. The screw breech-loading arrangements will be readily understood by a glance at the woodcut. The breech-screw S, which is tightened or released by the lever L, and tappet rings E, secures the vent-piece V, and thus closes the bore. The vent-piece is lifted out previous to loading, the projectile, lubricator, and charge being inserted from the rear through the hollow breech-screw. The portion of the chamber *a* next to vent-piece, is not rifled, in order to admit the shot freely; the rifling gradually increases in depth through the space *b*, till, at *c*, it attains its maximum depth. The vent-piece is faced with copper, which fits against a copper ring in the bottom of the bore. The gun itself is composed of the wrought iron coil-tube A, supported by the breech-piece P, the trunnion piece T, and the coils D C B.

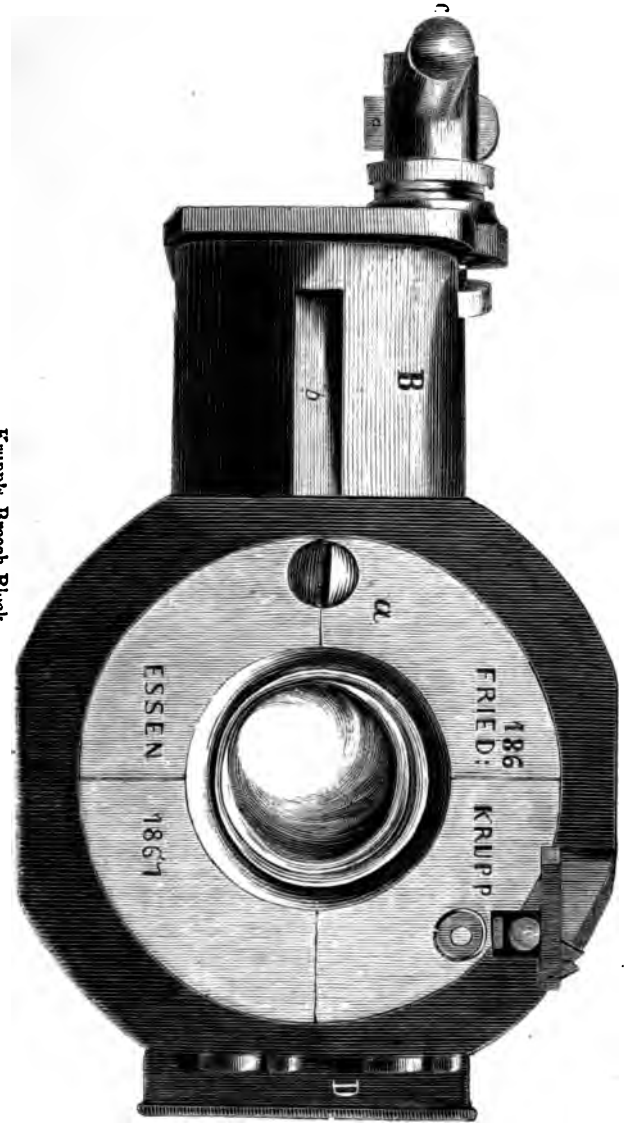
In the same department the Government exhibit several breech-loading field-guns of larger calibre, all on the Armstrong "vent-piece" or "wedge" systems, but containing nothing special or new

The trial will be for range, accuracy, and endurance, when some light French piece is to compete with the English weapon. It is only necessary to add, that the French field-guns, and indeed most of their siege and battery guns, are of gun-metal. The bore is larger in proportion to the weight of the piece than the Whitworth, the Armstrong, or Krupp's steel guns. One of the most interesting pieces is the small mounted gun-metal mortar already referred to.

In an economical point of view the French gain an important advantage by adhering to gun-metal for the material of their field-guns. Though these may be inferior in range to good iron or steel guns, or even be shorter-lived, they can be replaced at much less cost. The material can be used again and again, and the cannon renewed as often as may be necessary, for a small percentage over the cost of the labour.

With some points of resemblance, there is, nevertheless, a sufficiently broad line of demarcation distinguishing the chief exhibitors of field-guns in the Exhibition to entitle their productions to be considered as separate systems. If the Whitworth and Armstrong resemble each other in the mode of construction, there is a marked difference in the rifling; both differ from the French brass cannon, and all these differ from the steel guns of M. Krupp. These Essen guns are homogeneous—made of one material—and excepting the wedges and screws of the breech-loaders, of one piece of metal. With the exception of one small mountain gun, all Krupp's cannons are breech-loaders; and while the English gunmakers have come to the conclusion that breech-loading cannot be advantageously applied to heavy ordnance, or even to light field-pieces, Krupp has arrived at quite the opposite conclusion. Since the manufacture of cast-steel guns commenced at Essen, the establishment manufactured and delivered 3,500 pieces before the opening of the Exhibition, and they have (May, 1867) orders from European and other governments for 2,200 more. About nineteen-twentieths of these 5,700 cast-steel guns are rifled breech-loaders, ranging in calibre from 4-pounders to 300-pounders, with a few 600 and 1,000-pounders, their total value being about $8,500,000. These guns are rifled on the polygroove system, and use lead-coated projectiles. The illustrated breech arrangement shows

that they receive the shot and charge through the extreme end of the breech, which is the case with all Krupp's guns, except the 1,000-pounder. The breech-block B, is not drawn fully out in load-

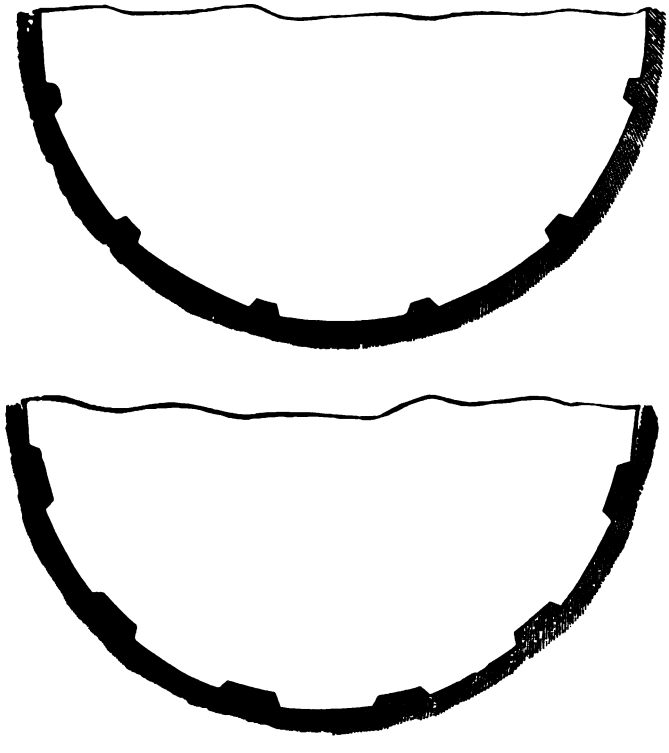


Krupp's Breech-Block.

ing, but only so far as to allow the shot and charge to pass through a hole in the end of the said block. The distance which this block can travel is regulated by the set-screw *a*

the point of which, when screwed up, enters the groove *b*. The engraving shows the end of the breech open, ready to receive the shot and charge. When the block is pushed in, a slight movement of the cross-lever handle, C, tightens it, by drawing home the wedge D: the gun is then ready for firing. A reverse turn of the same handle slackens the block after firing, and the mechanism is so nicely arranged, that none of the strain comes upon this handle or the screw attached to it. The breech-block, or wedge-opening, in Krupp's guns, was formerly square at the breech-end, with the corners slightly rounded off; but this form, under heavy strains, led to distortion of the bearing parts, causing difficulty in working, and ultimately resulting in the premature destruction of the gun. The opening now adopted is round at the breech-end as shown in the woodcut.

Breech.



Muzzle.

The rifling of Krupp's guns is polygrooved, and requires a lead-coated shot. The rifling is not so fine as in the Armstong breech-

Krupp's Field Gun.

loaders, nor does the coating bear throughout the whole length of the shot, as in the Armstrong, but only on four points or rings, which project about the depth of the grooves beyond the general surface. The *initial* strain of forcing this lead-coated shot into the grooves of the rifling is greatly relieved in Krupp's system by the *lands* being very narrow at the breech, and widened towards the muzzle as shown in the foregoing diagrams.

A four-pounder rifled breech-loading field-piece of crucible steel is exhibited mounted on a wrought-iron carriage of Krupp's make. This 'gun, represented in our illustration, is the property of the Prussian War Department. The gun, including the breech arrangement, weighs 605 pounds, the diameter of the bore is three inches. It is seventy-four inches in total length, and is rifled with twelve grooves. The weight of the shell charged is eight pounds and a half, and the charge of powder is one pound. The system of breech-apparatus is "Krupp's patent semi-cylindrical wedge," or block, already referred to, fitted with a Broadwell ring. This gun, with several others of a similar make, all Krupp's, have been subjected by the Prussian Minister of War to severe tests. They have been fired several hundreds of times each, with gradually increasing charges up to three and three-quarter pounds of powder, and 122 pounds' weight of shot. In no instance was the gun or breech-apparatus injured, and the field-gun exhibited came from the proof in its present condition. So far, M. Krupp's light cast-steel guns have given full satisfaction, but whether the same material be as suitable for siege, naval, and battery guns of large calibre, will be inquired into when these guns come under consideration. One grand feature in favour of Krupp's guns is their homogeneity. Both these and Whitworth's (which contains a greater proportion of steel than Armstrong's) have shown a capacity for greater endurance than the general run of wrought-iron guns. Still the Krupp and Whitworth guns, though possessing greater endurance, have, as already observed, the disadvantage, as compared with the Armstrong, of giving no warning (such as might be observed on service) of the approaching destruction of the gun. In this respect the unreliable nature of steel tells more severely against Krupp's guns than those of his English rivals. But in an establishment

like that at Essen—which produces 60,000 tons of manufactured steel annually, much of it for the most important duties of the mechanical world,—it is highly probable that the manufacture of cast-steel for guns will ere long reach a satisfactory uniformity of texture—a uniformity that will enable steel guns to equal, or rather surpass, wrought-iron or brass cannon in reliability, as far as they now surpass them in sheer strength and endurance.

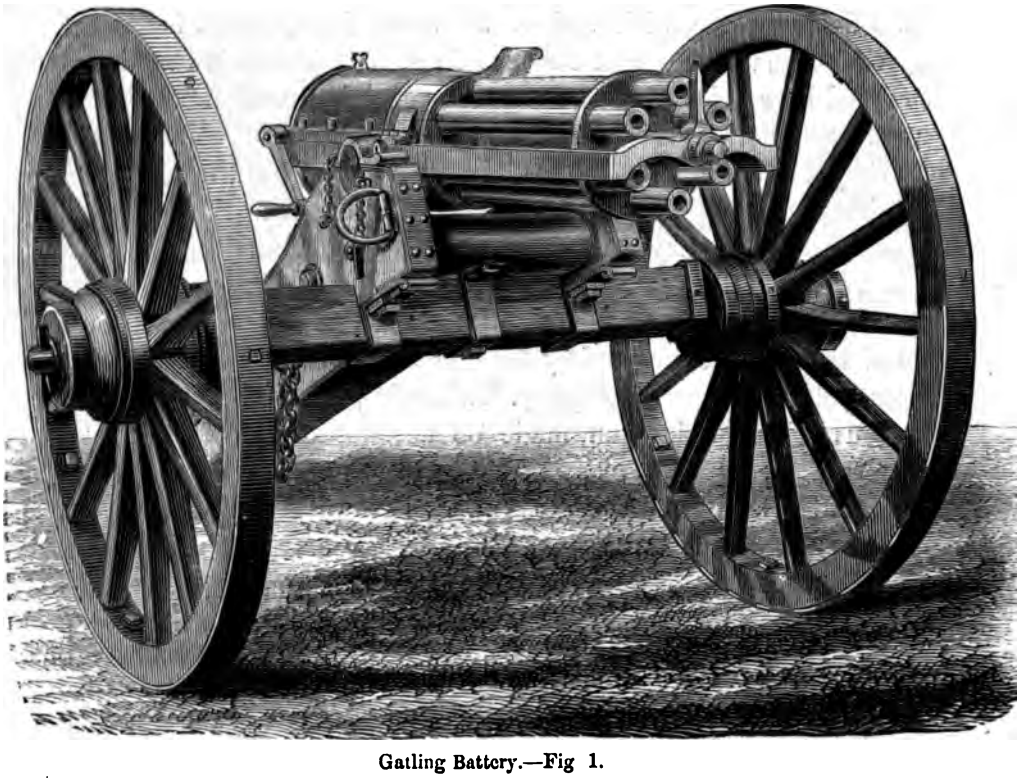
Some old brass and cast-iron smooth-bore guns, which have been filled with molten gun-metal bored out and rifled, are shown by the Government of the Netherlands. The cast-iron gun, formerly a six-inch smooth-bore, enlarged to six inches and a half, has now a calibre of five inches, which leaves a brass lining of three-quarters of an inch thick. This gun is rifled with six grooves; whether from the shrinkage in cooling, or the want of affinity between the two metals, the brass tube does not fit very snugly. There are traces of wedging and caulking about the muzzle that look suspicious. It is not stated that the gun has been proved, or even fired, and its appearance, taken altogether, holds out little hope that old iron smooth-bore cannon can be rifled and made to stand the strain of heavy charges and heavy shot by lining them with a foreign metal in this manner. The case, however, is different with the gun made of gun-metal. After experimenting for several years, a perfect adhesion between the metals was finally obtained. One of the guns exhibited was filled up solid with a similar metal, bored out and rifled. The weight of the piece before filling was 763 pounds, and after it was rifled, 837 pounds. The gun was fired 2,000 times without receiving the slightest injury. It was then cut in two longitudinally and sent to the Paris Exhibition. Though the union of the two metals can be distinctly traced, it is also evident that the adhesion is perfect. Still it is doubtful if ever this method of lining guns will be of much service. It seems as if it would cost little if anything, more to recast the entire gun anew. When it is considered that this operation of filling, after boring and rifling, adds only seventy-four pounds to the weight of the gun, and that even with the greatest care faults are more likely to arise than in casting the gun anew, the latter seems to be the most sensible and the safest method.

The only field-gun in the American Section is the "Gatling Battery," exhibited by Mr. R. J. Gatling, of Indianapolis, Indiana, and in artillery weapons it is, if not the only novelty, at least the greatest in the Exhibition. Its main features consist of six separate barrels revolving around a central axis, the breech end of the barrels being covered by a stationary metal cylinder in which the mechanism of the gun works and is protected. The gun is mounted on a field-carriage, with trail of the usual form, and it is secured by the ordinary caps over the trunnions. The breech is raised and lowered by an elevating screw. The revolving portion consists of a lock-cylinder, carrying the loading and firing mechanism. The gun is put in operation by the turning of a crank, but the action and mechanism, though very simple compared with the work performed, would require a somewhat lengthy description and many illustrations. The two batteries exhibited are six-barrel guns, the largest being one inch and the smallest ·58 in. bore. They are part of a lot of 100 batteries ordered by the Government of the United States from Colt's Fire-arms' Company. This order, it is said, resulted from various trials of the gun made on account of the Government. During the present year one of these guns was tried at Shoeburyness, and the following from the *Army and Navy Gazette*, is a summary of the result:—

"The specimen of this gun now brought over to Europe is one of the first made, and is not as perfect and as good in material and workmanship as those which are now being made by the Colt's Company for the American Government. Nevertheless, it is sufficient to demonstrate the value of the invention. At the trial, which took place on the 7th instant, before the Ordnance Select Committee, the gun was fired at the range of 150 yards with case shot, and 800 yards with solid shot, giving a good target in both cases. At 150 yards the gun disposed of ninety-six cartridges in one minute and twenty seconds, but as, owing to an accident, one of the barrels could not be fired, twenty of the cartridges dropped out unexploded. The seventy-six effective rounds discharged 1,216 bullets, 668 of which were counted on the target. The strong wind blowing at the time no doubt drove a great many of the light bullets to the right of the target. A second trial of the gun took place at Shoeburyness, last Tuesday, before the Egyptian Commander-in-Chief his Excellency Chahine Pasha, who wished to acquaint himself with the construction and performance of the gun. One of the barrels being still unable to explode the cartridges, the fire of the

gun was materially impeded thereby. The large bore Gatling gun, if fired with solid ball, is said to make a good target up to 2,000 yards."

The following is a fuller account of the same trial from the London *Standard*, which, with the accompanying engraving, Fig. 1. will give a tolerably fair idea of the nature of this arm and its capabilities :—



Gatling Battery.—Fig 1.

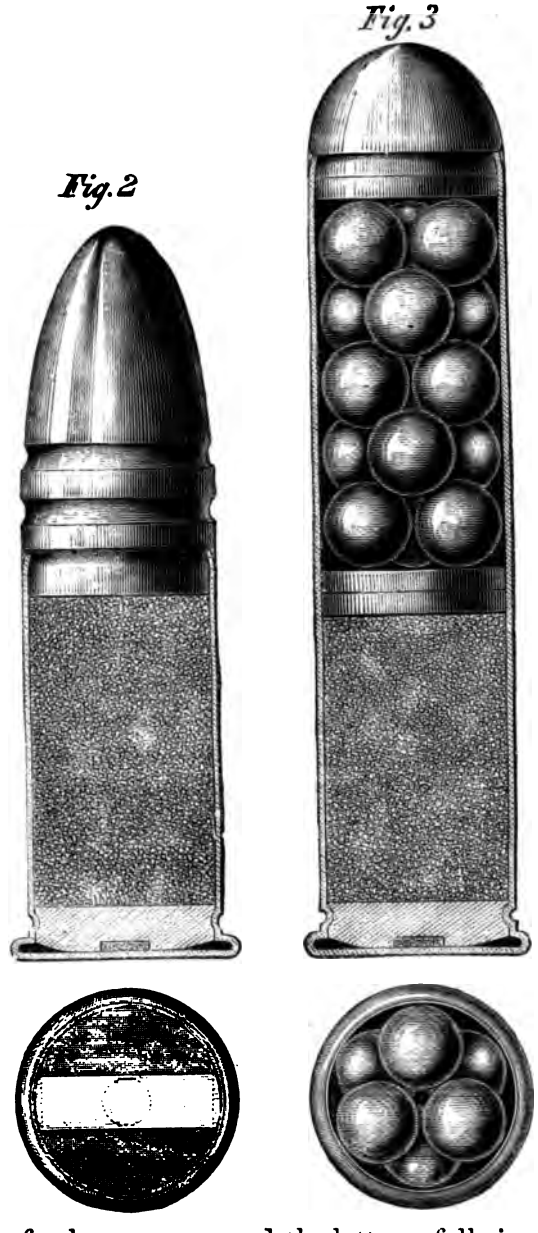
"Gatling's battery-gun is an American automatic machine-gun, loading and firing incessantly, the cartridges being supplied from tin feed-boxes, from which they are run into a slot in the breech-cover, whilst the battery of six steel barrels, secured in position in front and behind by two metal plates, is made to revolve by the turning of a handle. The six barrels discharge metallic cartridges, and have six cylindrical plungers to close their breech ends, each fitted with a horizontal piston or striker, working longitudinally through its centre, to explode by the force communicated by a spiral spring the fulminate in the cartridge. The diameter of the bore of these barrels is one inch; and the cartridges are of two varieties. Both

are designed upon the same plan, and differ only in the nature of the projectiles with which they are loaded. A stout copper cylinder, furnished with a rim for the grip of the extractor, forms the case. Across the rear-end of the cartridge-case there is an internal iron bar, having a small cell scooped out on one side. This is filled with fulminate, and the bar is held in position by the indentation of the copper case along a line of about a quarter of an inch on each side into grooves at its ends, the fulminate facing the inside of the metallic rear-end of the cartridge, which, in the act of firing, is driven in by the piston upon the fulminate. One variety of cartridge carries a single solid lead shot about two inches and a half in length, and weighing seven ounces and a half; the other is a longer cartridge, closed by a smaller point ball of two ounces weight, but carrying within the case, between the powder and the point, fifteen small bullets of thirty-two to the pound. The solid shot cartridge has a charge of three-quarters of an ounce of powder, and the compound cartridge has the same charge. The Gatling gun was in charge of U. S. General Love and Mr. Broadwell, and is of a pattern that has been adopted by the American Government, one hundred having been ordered of Colt's Fire-arms' Company, at Hartford, Connecticut. To convey a brief popular notion of the Gatling gun, one might say that it was an infernal machine combined of six large needle guns and a Colt's revolver. Such would not be a strictly accurate description, but it would convey a general rough idea. The gun was fired from 150 yards' distance, at a frontage of fifty-four feet of two-inch thick target, nine feet in height, and in one minute twenty seconds disposed of ninety-six cartridges. Of these, seventy-six were exploded, and twenty were miss-fires. The number of missiles discharged by these seventy-six effective rounds would be 1,216, of which 628 were counted in the targets—namely, twenty-six point balls through, 443 lodgers, and 159 struck. There is no doubt, however, that the bullets being light, the strong wind that was blowing carried a good many of them to the right of the targets, and this proportion of what should have been the proper tale was thus eliminated. The penetration, however, was very slight, most of the bullets lodging in the wood, and also being, from the softness of the lead, greatly distorted in shape by their jamming together in the gun at the time of discharge. If the bullets had been hardened as those used in our own service are, and if they had been packed with coal dust or other material to keep them in place, better results would undoubtedly have been attained; as it is, the gun must not be blamed for the defects of the ammunition. Against this Gatling gun an Armstrong 9-pounder field-gun was fired with Lieutenant Reeves's case-shot, the powder charge used in the gun being one pound two ounces, and the shot being eleven to the pound. Seven rounds were fired in the same time—one minute twenty seconds—and consequently as each case

shot contained sixty-eight bullets, 476 projectiles were discharged. Two of the case-shots, however, passed bodily through the target, and therefore the total of missiles must be reckoned at 360. Of these, 184 passed through the target, ten were lodgers, and two struck. The case-shot used in this instance was somewhat adverse to a fair criterion on behalf of the breech-loader, as Lieutenant Reeves's case-shot of sixteen to the pound, with the interstices utilised with buck-shot, would have been more on a par with the numbers and dimensions of the bullets in the Gatling ammunition. The Gatling gun weighs 9 cwt.; the Armstrong 9-pounder, 6 cwt. On a repetition of the firing of the Gatling gun about twelve point balls passed through the target, and there were 416 of the smaller bullets lodged, and eighty-six struck. This last practice told in the centre of the targets, and gave a very good diagram.

The Gatling gun was next tried at 800 yards with solid lead shot, going through its 149 rounds in one minute and forty-seven seconds. Of these, 117 rounds were discharged and thirty-two were miss-fires. It is only justice to say that in these miss-fires are included the cases arising from the dropped cartridges of one barrel, which had its striker broken, as well as those occurring through the fulminates of the cartridges not exploding. Of these 117 shots discharged, forty-one passed through the target and one struck. All these were driven to the right hand of the target by the wind. Against this the Armstrong 9-pounder at the same range. with a powder charge of one pound two ounces, firing Armstrong field-service segment shells of forty-one segments, with percussion fuses, to act on graze, got through four rounds, and all but a fifth, in the same time (one minute forty-seven seconds). Seven rounds could probably have been done had not the wind taken the smoke of the discharges directly along the road towards the targets, and thus preventing for considerable intervals the re-sighting of the gun. The fragments of the shells would in this case add to the number of the missiles. One hundred and three holes were counted in the targets, thirty-seven lodgers, and thirty-one struck. Without wishing in any way to slight a very ingenious invention, so far as these experiments went, they certainly showed a marked superiority of our own guns and ammunition for field-service. The Gatling gun is nevertheless a formidable weapon, and for trenches or a breach, and for street fighting, would do execution; but we doubt if its best effect would be as powerful to check the advance of troops as the bursting of a good shell on the head of a column. Certainly the little amount of recoil, and the consequent advantage of retaining a tolerably accurate direction after being once sighted, might prove a valuable element, and in certain cases would give an advantage not possessed by ordinary cannon, which have to be re-sighted after each discharge; and which, when the smoke of action is dense, it is simply impossible to do otherwise than by guess."

Figs. 2 and 3 represent the cartridges described in the above extract. The former being a full size section of the solid



ball cartridge for long ranges, and the latter a full size section of the small bullet, or case cartridge.

The advantages claimed for this gun are rapidity of firing, and good practice; also that the gun and carriage, as compared with ordinary guns, are so much heavier than the barrel which is being fired; there is no recoil, hence the aim, once taken, is not disturbed. It is also said that it can be worked by a small complement of men. The 668 hits, at 150 yards' range, made at Shoeburyness in one minute and twenty seconds fully equal what could be performed by fifty riflemen with good breech-loaders in the same time. There is little doubt that the rifle bullet would be more effective than the Gatling half-inch sphere of lead, at this short range, and even at from 300 to 500 yards the rifles would doubtless be more effective than the case-shot of the battery. But at greater ranges the solid shot of the battery would certainly be more effective than the rifle bullets. There can be little doubt that this weapon possesses special advantages for certain purposes and positions—such as defending flanks, narrow passages, or bridges in case of assault. But even with solid shot it will probably be inferior, at ranges over 1,000 yards, to the Case-shot, Shrapnel, and Segment shell, of such field-guns as we have been considering. The Gatling gun, however, should not be compared with breech-loading rifles on the one hand, or field ordnance on the other. It has a special mission of its own, and is likely to have an important influence on future battles—an influence which will materially affect the disposition of troops, the working of field guns, and military tactics in general. Since the trials at Fort Monroe, it has been adopted as a regular arm in the American army. The gun was taken out of the Exhibition by the order of the French Government, and subjected to a series of trials at Versailles,* at most of which the Emperor assisted personally, and took the greatest interest in the proceedings. One of the greatest military powers of Europe has lately, and doubtless in consequence of these trials, ordered one hundred of these batteries. In the absence of the official reports of these French trials we append a table of one of the Fort Monroe experiments with the Gatling battery. In the Report accompanying it the commanding officer who conducted the trial says:—"The moral effect of the Gatling gun would be very great in repelling an assault, as there is not a second of time for the assailants to advance between the disch-

* See Appendix.

The following is copied from the official Target Record of firing with Gatling's Breech-loading Repeating Gun, made at Fort Monroe Arsenal, Va., from June 21st to July 7th, 1866, to test its merits with 24 Pdr. Howitzer for flank defence.

No. of Trials.	No. of Fires.	Time, 1866. Month.	Day.	Powder. Kind.	Wt. Lbs.	Oz.	Projectiles.	Elevation, in degrees.	Wind, Strength and Direction.	No. of hits on Target.	Time occupied in firing.	SPECIAL REMARKS.
1	73	June	21	Musket.		4/5	Buck-shot Cartridges.	0° 55′	M Rto F.	278	1′ 30″	
2	74	,,	22	,,		4/5	,,	,,	,,	322	1′ 30″	Gun oiled and cleaned before firing.
3	101	,,	26	,,		4/5	,,	0° 50′	C.	691	1′ 30″	
4	29	,,	30	,,		4/5	,,	0° 30′	M.F. & L.	291	0′ 22½″	3 or 4 seconds lost by reason of defective case.

Kind of Cannon - - - Gatling's Breech Loading Repeating Gun.
Diameter of Bore - - 1 inch—6 Barrels.
Weight of piece in lbs. - 800.
Character of Rifling - - Uniform.
Kind of Carriage - - Wooden Field Carriage.

GENERAL REMARKS.

Target 4 8 6 feet, in 4 sections of 12 × 6 feet each, placed 200 yards distant from gun. Ground rolling between gun and target.
At third trial, target placed 150 yards from gun.
At fourth trial, target placed 100 yards from gun.

DESCRIPTION OF CARTRIDGE.

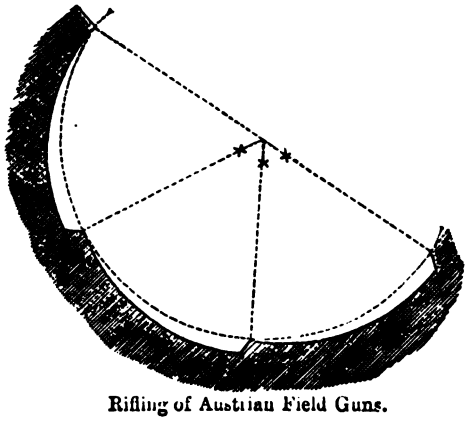
15 bullets, ·48 and ·50 of an inch in diameter.
2½ oz. lead in one point ball, making in all 7 oz. of lead.
Cases made of No. 18 sheet copper.
Length of case 4.2 inches.
Diameter of case, 1 ,,
,, of head, 1·15 ,,
Weight of case 1 oz., 272 grains.

CHARGE.

Powder, 3-4 oz. Musket Powder.
Entire weight of cartridge, 9½ oz.

(Signed) **T. G. BAYLOR,**
Capt. of Ordnance, and Bvt. Col. U. S. A., Commanding.

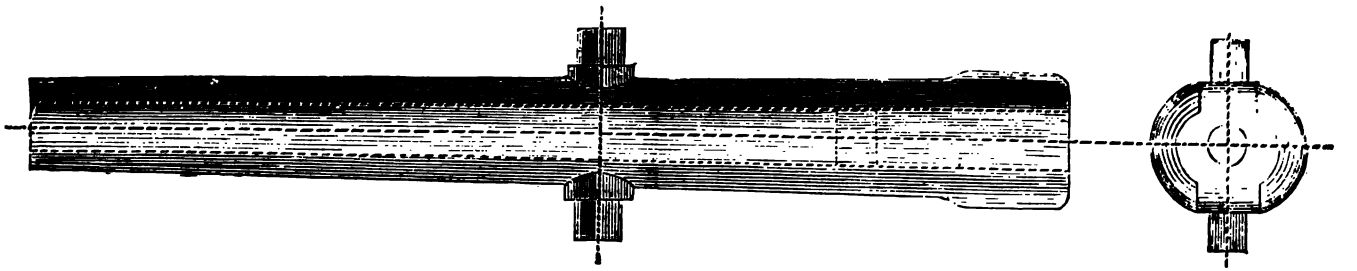
The Austrian Government show three field-pieces mounted and highly finished. They are all bronze guns and muzzle-loaders. The largest, which they designate an eight-pounder, looks more like a twenty-pounder. The rifling and equipment of these guns are after the system recommended by the Austrian Committee of Artillery. The rifling is what is termed in England the Scott or saw-shaped system, having a bearing on one edge of the groove only, as represented in the diagram.



Rifling of Austrian Field Guns.

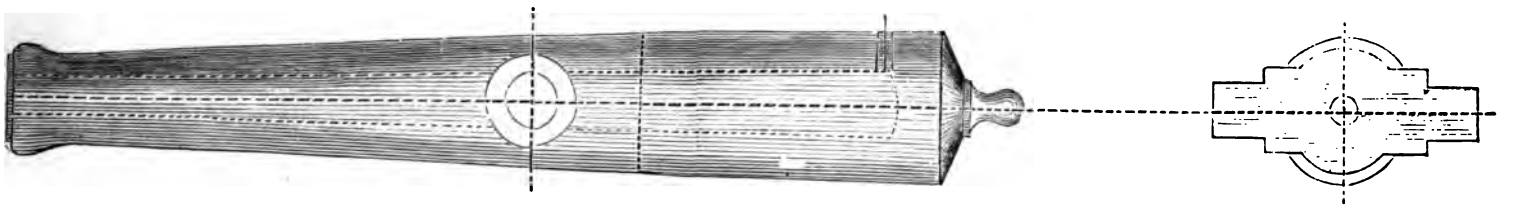
The twist of the Austrian guns is uniform. The elevation is given by a handle worked outside of the left cheek of the trail. The gun carriage is of wood and has a heavy, unmanageable look compared with the elegant iron carriages of Krupp or Armstrong. The wheels of the carriage and ammunition-waggon are, to use a rail-road phrase, of broad gauge, which gives great steadiness in driving over rough ground, and also affords space for a large ammunition-box, on which four men can sit abreast. The trail of the gun-carriage is not, as usual, attached to the axle of the ammunition-waggon beneath, but it is kept about level, and rests upon a shelf projecting in rear of the waggon (to which it is attached by a bolt and lynch-pin), evidently for the purpose of affording the means for a seat to a couple of men—a very uncomfortable leather-covered seat being fixed on the trail midway between the gun and ammunition-box. A four-pounder similarly mounted is shown beside this gun, also a three-pounder packed on, and lying lengthwise *across*, a saddle. A second saddle is packed with the carriage and wheels. The carriage, in this instance, is very light and elegant, made of iron or steel, and even with its wheels seems to be a more comfortable load than the gun. The ammunition forms a third load, and all the saddles appear to be intended for heavy horses. These

Fig. 1.



Berger Steel Gun (breech-loader).

Fig. 2.



Berger Steel Gun (muzzle-loader).

Austrian field-pieces being of greater calibre than the steel guns of the same weight manufactured by Krupp, and used extensively in the Prussian army, will be more effective at short ranges, but at any distance over 1,500 yards they will doubtless be inferior to the steel gun, both in range and accuracy. These qualities, now-a-days, are the grand *desiderata* in field ordnance. A battery cannot now take up a position, as in days gone by, within half a mile of the foe, and calculate upon holding that position against anything save a successful charge by the enemy. The great range and accuracy of modern infantry arms would render their position untenable; so the improvements in small-arms demand corresponding improvements in field artillery.

Some field-guns are exhibited by Messrs Broadwell and Co., of Carlsruhe. They are steel guns, of uniform polygroove rifling, mounted on iron carriages, and have the wedge breech-loading arrangement generally in use in German guns. To these, in this case, is added the well-known Broadwell cap, or expansion ring, and which so effectually prevents the escape of gas without requiring a mechanical fit of the breech-parts. This ring or cap is simply a flat circular plate of iron or steel, having a thin flange on one side like the cover of an ordinary tin can. This flange fits into the breech of the gun next the charge of powder, and the flat surface of the cap or ring rests upon, or is attached to, the breech-block or wedge. The explosion of the charge expands the flange of the ring, which prevents the escape of gas breechwards, and when the force is expended the flange returns to its normal state. This arrangement, as we have seen, is used by Krupp in some of his guns, and also by Berger and Co., of Westphalia. Berger and Co. exhibit some good-looking steel guns alongside of the more attractive display of M. Krupp. There is a severe simplicity about these Berger guns, and about German guns generally. The opposite sketch, Fig. 1, shows the outline of a Berger breech-loader on the Broadwell system. Sometimes this extreme simplicity is departed from, as in the case of the gun shown in sketch fig. 2, a muzzle-loader manufactured by Berger and Co. for the Government of Switzerland. These guns are about 700lbs. weight each, and 3·35-inch bore.

Regarding the heavier pieces of field ordnance, there is really nothing in the Exhibition calling for special notice except a mounted mortar in the British Section. It is a cast iron ten-inch mortar weighing 18 cwt. (2,016lbs.), mounted on a solid bed, or block, of timber about five feet long, two feet nine inches wide, and eighteen inches thick. This block, strongly hooped with iron bands, rests upon an axle limbered in the usual manner to an ammunition or shell-waggon. This is fitted with shafts for three horses abreast, if necessary, but two, on fair ground, are sufficient to transport the piece. When the mortar is to be fired the carriage is unlimbered and tipped up until the rear end of the mortar-bed or block touches the ground, the trail is then raised so as to lift the axle, when the wheels are removed and the mortar carriage lowered to the ground. The whole operation occupies about a couple of minutes. This piece of field artillery is new to the British army. It was not in use during the Crimean war, or even the late Indian mutiny, having been adopted into the service only a few years ago. Some handy mortar such as this, and a light mountain-gun possessing great range, such as Mr. Whitworth's two-pounder steel-gun, seem well adapted for Indian warfare in the West. The case-shot of the latter especially will deserve more than a passing notice when we come to speak of projectiles.

There is a gun of considerable promise in the Exhibition which has already been mentioned, and which contains some novel and interesting features of construction. Being at present in the form only of a good-sized working-model, and capable of being adapted both for land and naval service, it may properly be introduced here. The "Ferris gun," exhibited by Mr. G. H. Ferris, of Utica, New York, in Class XXXVII., is described in the official catalogue as a "wrought-iron breech-loading rifled cannon." Certainly there is still ample room for a good wrought iron gun, if such is ever to be made. If England may be said to excel in any branch of the iron trade, it is in the production of heavy wrought iron forgings; and yet no really reliable wrought iron gun has been produced in England. The experimental guns of four or five years back have disappeared one by one, and the hospital for incurable ca
Woolwich is beginning to assume alarming dimensio

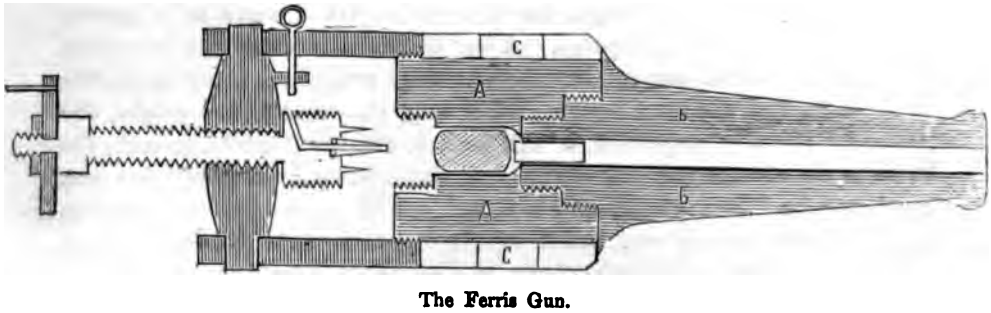
write we learn from the *Army and Navy Gazette* that one of the 18-ton 10-inch Woolwich guns, said to be rifled on the Lynall Thomas system, has burst at Shoeburyness after a few rounds, blowing the breech explosively to the rear; thus proving that there are exceptions to the "gradual destruction" theory put forth on behalf of wrought iron guns. Recently a 23-ton 600-pounder gave way, after no more than fifty rounds. The cause of this failure of the Armstrong-Woolwich, or Fraser system of gun construction, may engage attention in a more special manner in connection with Battery and Naval Ordnance. We were led to refer to these failures now, because the Ferris system of construction seems to provide a remedy for such apparently inherent defects in wrought iron cannon. Before adverting to what we regard as the most important point in the construction of the Ferris gun, the following remarks from "Greener's Gunnery" will illustrate the evil which this system seems destined to cure:—

"Professor Barlow, many years ago, proved to the satisfaction of the Institution of Civil Engineers, that the metal in any cylinder decreases in utility in proportion to the square of its distance from the centre; that the outside of a gun of the form now used, in fact, is only one-ninth as useful as the inside, being three times as far from the centre. If we double the thickness, the outside, being five times as far from the centre as the inside, will be but one twenty-fifth as useful, or in plain English, nearly useless. The reason of this is simple, and I will endeavour to explain it. A bar of cast iron, one inch thick each way, and forty inches long, will stretch about one-twentieth of an inch if a weight of about four tons be suspended by it. When the weight is removed, the cast iron nearly recovers its previous form, and is uninjured, but if it be stretched more by a greater weight it is permanently injured. A bar of the same thickness, but three times as long, 120 inches, will stretch three times as much, or three-twentieths of an inch, with the same weight; or if only one-third of the weight, one ton and a third, be suspended, it will stretch one-twentieth of an inch, the same as the shorter bar. If we suspend sixteen tons by four bars one inch thick and forty inches long, they will each stretch one-twentieth of an inch only, and remain uninjured, but if we attempt to do so with two bars forty inches long, and two 120 inches long, then, when the whole have lengthened one-twentieth of an inch, the short ones are exerting a force of eight tons, but the long ones that of only two and two-thirds tons. The weight, therefore, will still further lengthen the bars, and permanently injure the

short ones; perhaps break them first and then the long ones. This is the way a gun is burst. The inside is a series of bars of iron, say forty inches long, in the form of a ring, the outside a series of rings, representing the bars, three times as long."

To bring these several bars or rings to bear their fair share of the strain, Mr. Ferris forms the core of his gun of concentrated wrought iron rings, discs, or washers, of different qualities of iron, the softest inside, and forged around a small mandril or centre, which is afterwards all bored out in boring the gun. Each ring or washer, however, as it is made, has a mandril with very little taper driven into it until its outer circumference begins to enlarge, by which means the entire ring, or washer, is brought to support its share of the strain. The following description of the gun and its manufacture is extracted from documents furnished by the inventor, and Mr. Macomber, who represents him in Paris, to the United States Government. The chief features of the gun are summed up thus:—It is manufactured of wrought iron and steel; it is a chambered gun; diameter of bore one inch and three-quarters; spherical ball to fill bore weighs ten ounces; smallest sized conical ball twenty-seven ounces; full capacity of chamber in powder twenty-seven ounces; average diameter of a cone-shaped chamber, two and seven-eighth inches; length of the chamber, seven and a half inches; whole depth of bore thirty-one and a half inches; distance the ball travels in bore, twenty-four inches.

Our woodcut represents a 100-pounder on the Ferris principle



The Ferris Gun.

on a scale of three-eighths of an inch to a foot. The bore of this gun would be six inches, and the charge of powder fifty pounds, which

Mr. Macomber believes would give an initial velocity of 2,200 feet per second, and at thirty-five degrees elevation, send a shot or shell ten miles. The chamber and barrel of the gun, A, *b*, is of wrought iron, hooped with the steel rings, C. "Mr. Ferris," says our authority, "has built the barrel of his gun of the best wrought iron bars, all welded together, the softer at one end, and growing harder towards the other end; then coiled into the form of a watch-spring, then hammered into a flat washer-like ring, the softest iron forming the inner and the hardest the outer circle of the same. These rings are passed through rollers and brought to a uniform thickness and an even surface. They are then laid together around a mandrel-bar, forged and thoroughly welded together, with heavy longitudinal and light vertical hammering, until a solid mass is formed, which after being bored, chambered, rifled inside, and perfectly engine-turned outside with a true taper from the breech to the muzzle, forms the core or heart of the barrel. The covering of this core is formed by a series of heavy steel rings, mechanically turned, inside and outside, and the inner surface made to exactly fit the core, the larger at the breech and the smaller at the muzzle, the rings being firmly secured in a peculiar manner to prevent loosening by the concussion of the discharges. The steel rings are lubricated and forced into their places by a screw and clutch, and they can be removed by the same means, two or three men easily working the screw. The breech-chest is of wrought iron, and attached by heavy flanges and bolts. Through the breech-chest the screw plunger is worked by a double screw, and driven in the rear by a bar-wheel, five turns of which by the gunner will leave the chamber open for the insertion of the shot and charge, and the like number of turns drive up and secure the same. The upper end of the plunger is fitted with detachable steel plates, so arranged as to exactly fit the chamber of the barrel, and being bevelled at the end, they cut away all fouling of the chamber, being bolted to a metal plug which, firmly entering the base of the chamber, forms with the slot-plates a perfect prevention of the escape of gas."

The following refers to the several trials of this gun made in America before it was sent to the Exhibition:—"On February

25th, 1863, we tested the Ferris gun on the frozen surface of Oneida Lake, in Madison County (New York), firing at a target at one thousand feet measured distance, and in repeated experiments found the fall of the shot to be four feet six inches from the gun level in that distance."

"May 29th, the first trial of the Ferris gun was made at the Navy Yard, Washington, in the presence of the President.

Record of shots for range.
At 4° elevation .. 2,850 yards.
„ „ .. 2,750 „
Weight of ball, two and three-quarter lbs.—Powder, twenty-four ounces,
Trial for penetration, June 16th, 1863,

Ferris Gun.	Muzzle Loader.
Distance .....50 yards.	Distance .....50 yards.
Weight of ball ..3.71 lb.	Weight of ball ..3.71 lb.
„ Powder ....24 oz.	„ Powder .....4 oz.
Penetration, Wrought Iron .....3 in.	Penetration .....½ in.

"By a General Order from the Ordnance Department, June 23rd, signed by General Ripley, the Ferris gun was removed to West Point to test the initial velocity."

At the first trial, the initial velocity was 2,200 feet per second.

"Under the General Order of June 23rd, the gun was taken to Fire Island as the most suitable place for range firing.—August 1st, the trial was conducted by Mr. Macomber and the inventor. This firing was kept up at intervals, when the weather would permit, till September 4th, and was witnessed by many scientific and practical military men with the following results:—Elevation thirty-five degrees, weight of ball three pounds, powder twenty-four ounces, distance nine miles."

This gun, after 147 rounds, is as perfect in all its parts as when taken from the workshop. The inventor, and his representative at the Exhibition, believe "that a cannon built on this system, with a chamber having capacity for fifty pounds of powder, could project a shot of 100 pounds weight through at least twelve inches of solid iron, and if the gun were elevated to thirty-five degrees, that it would throw a shot or shell ten miles." The

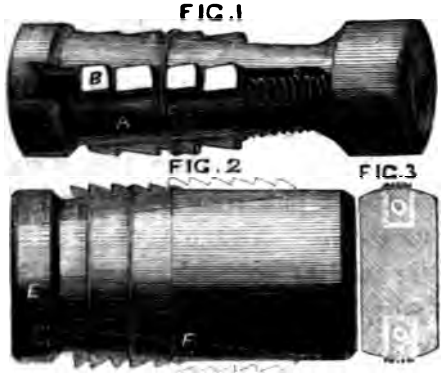
weight of such a gun would be from eighteen to twenty tons; diameter of bore six inches, and size of chamber ten by eighteen inches.

It is much easier to conceive that a shot having an initial velocity of 2,200 feet per second from a gun elevated thirty-five degrees might have a flight of nine or ten miles, than that a six-inch projectile of any known metal could penetrate a twelve-inch solid iron plate. Work sufficient to accomplish such a result might possibly be stored up in a projectile of 100 pounds' weight. But can any metal be found *hard* enough and *tough* enough to stand the shock of conveying this work to the plate without the shot itself being broken up or distorted? If the penetration of a twelve-inch plate by a six-inch shot be only the dream of a sanguine inventor, there is no doubt about the nine mile range of this model gun—a gun that can throw its shot and shell into a city, the inhabitants of which can neither see the smoke, nor hear the sound of the firing.

An article in "Bradshaw's Hand-Book of the Paris Exhibition" concludes, "such is this remarkable implement of destruction which seems calculated to effect as great a change in the art of gunnery as printing in literature." The Ferris gun may not be all that this sentence implies, and it may, like many other inventions, come short of the inventor's expectations, but unquestionably it contains the elements of a more *reliable* system of constructing wrought iron guns than has yet been produced—a system which deserves, and will doubtless receive, attentive consideration.

Near the Ferris gun lies a "Cannon destroyer" invented and exhibited by M. A. Bonzano, of Detroit. The following brief description of this invention was, during the war, published in the scientific journals of our own and other countries. The main portion A, consists of wrought iron. This is turned and grooved on three sides to receive the serrated slides B. These slides are held in place by the wire C, slipped over them, and by being fitted in tapering grooves will accommodate themselves to wide ranges of calibre. The springs D, *give*, as the spiker is pushed in, butt-end first, or with the teeth protruding towards the muzzle. These teeth have a sharp rake or angle outwardly, so that the least

attempt to pull the instrument out, causes them to cut into the bore and jam fast. The tapering form of the plug A, also serves to wedge the cutters out so that it sticks tighter with every attempt to dislodge it. Figures 2 and 3 represent a spiker for guns of large calibre; parts on the side are cut away so as to make it lighter and easily handled by one man, and the forward end E, is of hardened steel, so that it cannot be cut or drilled out; the dotted lines F, show the position of the cutters when the tempoary wire is broken and they are pushed back. These spikers can be kept ready for use in the caissons. At the trial of this invention the spiker was inserted in a 6-4-inch gun; a bag of eight pounds of powder was previously put in the gun. The explosion moved the spiker two and a quarter inches forward, where it lodged, the gas going out at the vent and past the spiker. The gun was subsequently removed to the machine shop where every attempt to remove the spiker from its position failed. This trial took place at the Washington Navy Yard.



Cannon Destroyer.

The Mackay gun which held out so much promise a year or two ago, is again attracting a good deal of attention. Though not in the Exhibition it should not be passed by in silence. With the Ferris gun, its proper place at present seems to be midway between field and heavy ordnance, with a tendency towards the latter.

The projectile—the immediate instrument of destruction—is held by artillery authorities to decide the nature and conditions of the gun, and Mr. Mackay's projectiles are of the simplest description, being merely smooth cylindrical bolts. The interiors of the guns are furnished with spiral grooves, and the gases escaping up these grooves communicate a rotary motion to the projectile. The advantages secured are that, with less strain upon the gun and less

weight of charge, there is a greater initial velocity, and greater penetrative power and range. The projectiles are made of one hard metal, incapable of expansion in the bore of the gun. They may be cast, and afterwards turned or not, as may be deemed necessary, and the absence of studs, buttons, or bars, for the purpose of giving a rotary motion renders them cheaper of construction than other elongated projectiles. Mr. Mackay contends, and cites his experiments in proof, that an elongated projectile proceeding from the windage gun at the initial velocity of 1,400 feet per second is immensely more destructive than a similar projectile without rotation with a flight of 1,600 feet per second initial velocity. He believes it is not possible to obtain the advantage of such a rotation upon the fixed projectile system, because the strain on the gun would be so great as to destroy it with a heavy charge; and even if the rifled gun stood a few rounds, the penetrative powers of the projectile, after it becomes disentangled from the fixed screwing process, would be very slight. He claims that his experiments have established that the force or striking power due to rotary projectiles, and the quantity of powder used for the charge, can only be obtained when the mean of rotation is imparted to it to coincide with the initial velocity.

At a recent trial of these guns, near Liverpool, there were three guns tested—one 8-inch, one 6-inch, and one 3-inch. The targets were four in all. No. 1 an 8-inch target, solid iron plating, resting on two flat balks of timber, 14 × 14, kept in its position in front and rear by two pieces of battens nailed, and supported at the top by a 14-inch balk which took in the head of the plate. No. 2 was the Agincourt target, a 5½-inch plate of rolled iron, backed with 9-inch teak, iron skin, resting on 14-inch balks, and kept in position by two other balks being braced to them. No. 3 was a 5-inch plate supported on both its edges by 14-inch balks. No. 4 was a 2½-inch plate.

The first shot fired was a solid cast-iron shot of seventy pounds, which was fired at a distance of seventy-five yards, from the 6-inch gun, with a charge of twenty-two pounds, against the 5-inch plate. The velocity may be estimated from the fact that it

passed clean through the target, making a circular hole. Portions of the broken shot, and a large piece of the target, were picked up at the distance of 1,000 yards (?) in a direct line from the target. The next shot fired was from the 8-inch gun at the same target with a spherical steel shot of sixty eight pounds, with thirty pounds of powder. It struck the target low down to the right, but the penetration was complete, and a large portion of the back of the plate surrounding the aperture was carried away. The third shot fired was a cylindrical steel bolt of seventy-four pounds weight, which was fired from the 6-inch gun against the Agincourt target, with a charge of twenty-two pounds of powder. This shot struck the target in its strongest part, and had it remained whole there is little doubt that it would have made a clear penetration. As it was the shot broke into two parts, one of which dropped in front of the target, and the other, though it went through the plate itself, lodged in the backing.

The fourth shot was a cast-iron cylindrical bolt of seventy pounds, with a charge of twenty-two pounds of powder from the 6-inch gun against the Agincourt target. The penetration in this case was not complete, but extended for two-thirds of the width, cracked the plate, and seriously damaged the backing.

The fifth shot was a spherical steel shot, fired from the 8-inch gun, with twenty pounds of powder, at the 5-inch plate. The plate was completely punctured, and a large amount of the metal and backing carried away.

The sixth was of the same character, with sixteen pounds of powder. It struck a perfectly firm part of the same target, through which it passed with equal success.

The seventh was a seventy-pound cast-iron spherical shot, fired at the 5-inch plate, from the 8-inch gun, with only fourteen pounds of powder. It struck the target to the right hand, close to the edge, and carried away bodily a mass of metal weighing at least 2 cwt.

This finished the first day's firing, the above account of which and what follows, was reported at the time in the London *Standard.*

"On Friday morning the experiments were continued in the presence of

Major Kleiker, of the Swedish embassy, and other gentlemen. The 6-inch gun, it will be remembered, was on Thursday fired at the Agincourt target, but the steel bolt did not penetrate beyond the backing. Mr. Mackay, in accounting for this, said that on the following morning he would send a bolt through. Accordingly on Friday morning he loaded the 6-inch gun with twenty-five pounds of powder, and a steel bolt of eighty-two pounds, by Firth and Co., of Sheffield, and directed it at a part of the Agincourt target which was still intact. The effect was tremendous; the bolt cut a clean hole through the front of the target, and tearing through teak, backing, skin, and all, was picked up eighty-six yards beyond, while a huge fragment of the target, weighing no less than 385 pounds was found at a distance of 290 yards beyond the target. The next shot was from the same gun, with a similar charge, and was directed at the 8-inch solid plate. The plate was not quite firm, and "gave" a little. The penetration was nevertheless, fully seven-eighths, and the plate was bulged and cracked from top to bottom."

The 3-inch gun tested for range at "high elevations" attained only the moderate range of 6,000 to 7,000 yards (a range inferior to that of the 15-inch Rodman smooth-bore at Shoeburyness with round shot) which was less than the great penetrating power of these guns would lead us to expect. The men who have served the Mackay gun complain that it is very hard work to get the shot home, but this, and doubtless other defects, could be got rid of, if only a tithe of the money spent on the Woolwich guns were spent on this. But whether Mr. Mackay's gun will overcome all the evils supposed to be inherent in rifled ordnance, remains to be proved. It has, however, done enough to entitle it to a full and fair consideration from all who are interested in the improvement of field or heavy ordnance.

CHAPTER IV.

HEAVY ORDNANCE

A FEW days before the closing of the British Parliament this year (1867) John Stuart Mill, in referring to the "Treaty of Paris of 1856," stated that,

"Twenty years ago a French writer remarked, that though the *art* of destruction was easy, yet the *science* of destruction was standing still, and bore no proportion to the activity of the other sciences, particularly the science of production. But what would the philosopher see now? He would see the inventive genius of mankind lending itself to the task of destruction, and bringing forward year by year more destructive engines to blast into atoms whole hosts of human beings, as well as the defence to which they trust. But ten years were passed in profound peace. Commercial intercourse, which we were in the habit of believing was the great safeguard against war, had been extended with the doctrines of free trade all over the world; and Protectionist opinions, which were calculated to render commerce provocative of war, had been discouraged all over Europe. And yet we were now engaged, not in diminishing, but in greatly increasing, our naval and military establishments. Our warlike expenditure was now twenty millions more annually than what had actually been the expenditure in the time of the present generation."

If France, by the construction of "La Gloire," induced Britain and other countries to build ironclads sooner than they otherwise would have done, on the other hand, the late American and Prussian wars, combined with the English experiments at Shoeburyness showed France the necessity of manufacturing heavy ordnance, and breech-loading small arms. When the Exhibition of 1867 opened, France, doubtless regarding it more as a peaceful display, made no show of heavy ordnance, and it was not till July, when a comparison with other countries put the French war material in the shade, that the Government finally determined to make up for lost time, and brought out their largest and best guns. Indeed, it

is generally believed, that some of the biggest of the guns now on the banks of the Seine under Bessemer's steel bridge, were manufactured since the opening of the Exhibition. But while such facts illustrate the productive capacity of the Imperial factory at Ruelle, they suggest a want of fairness to other exhibitors, who were required to complete their arrangements by the 1st of April. The Imperial commission, however, have taken the sting out of this seeming unfairness, by the liberal extension of similar privileges to others. If the French heavy ordnance appeared at a late period of the Exhibition, we shall only say "better late than never," and on the principle that the "last shall be first," we shall proceed, at once, to examine these late but welcome additions to the Exhibition of 1867.

The heavy guns for the French army and navy are chiefly manufactured at Ruelle, a town near Angoulême, on the main route from the latter place to Limoges. The selection of this site for the erection of workshops for this purpose, was due to two principal causes. First, the great hydraulic power derived from the River Louvre; and, second, the proximity of particular ores, which produced castings evincing a more than ordinary degree of resistance to the action of gunpowder. The vicinity having extensive forests, also affords an ample supply of excellent charcoal, the only description of fuel allowed to be used in the metallurgical operations connected with naval artillery. Ruelle, first converted into a cannon foundry by the Marquis of Montelambert, became a Government Arsenal in 1776. For a long period, even under the Government, the foundry was carried on in a very primitive manner. The cannons were run on the first melting in earthen moulds; they were sometimes cast with cores, and sometimes solid, in the latter case they were bored by means of a machine invented by the original owner, M. Montelambert. At length, the crisis arrived when France was imperatively called upon to take prompt and active measures in connection with her naval artillery, and to obtain as soon as possible six thousand pieces of ordnance. The establishments capable of contributing to the great national want were closely examined; intelligent emissaries were despatched all over the kingdom and elsewhere, and Perrier, Hassenfratz, and

Monge published works on the art of manufacturing cannon. The foundry at Ruelle was entirely re-modelled; two reverberatory furnaces and new casting-shops were added; tools and appliances of a more modern construction replaced those hitherto in use, and the works were conducted under the immediate superintendence of the State. Until the year 1823 the cannons continued to be cast after the first melting, but after that period a less primitive method was adopted. The canals, and general distribution of the water-power and supply, underwent considerable improvements. In 1840, the operations of bronze casting and boring, originally carried on at Rochefort, were transferred to Ruelle, and in 1846 a chemical laboratory was attached to the premises. Between this period and the present, the alterations and additions have been incessant, and similarly to Creusot and Essen, Ruelle grows larger every day, and blocks of stone, masses of béton, and the different elements of construction lying here and there, bear witness to the transformation in progress.

The greatest care is bestowed on the selection of materials at Ruelle, which may be classed under the following heads; charcoal, coke, coal, moulding sand or loam, fire-brick and burrs, castina or flux, iron ores and pigs. The charcoal delivered for sale at the foundry of Ruelle must be totally devoid of moisture, the existence of which is discovered by weighing samples selected from the quantity to be purchased. A certain number of cubic feet of material, packed pretty close, is weighed, and if the average weight exceeds twenty pounds per cubic foot, the seller is obliged to make a deduction on the usual price.

Coke is employed for a variety of purposes in the establishment. The furnaces, which are constructed on Wilkenson's principle, are fed with it, and it constitutes one of the elements in the composition of the crucibles; it is also pulverised and used in the moulding-shops, and forms an ingredient in the manufacture of various iron cements. Especial care is taken to ensure it being of the best quality, and the surveillance is of so stringent a character as to deter any one from offering it for sale unless fully convinced of its excellence. All substances of a sulphurous nature are particularly condemned, and the coke must not be too porous,

too much burnt, too soft, or too brittle. Formerly all the coke was procured from England, and the price delivered at the foundry was on the average 52s. the ton. Latterly coke of an excellent quality at a much lower price has been obtained from Aveyron, where they also obtain coal considerably cheaper than it could be imported from England.

A considerable variety of iron, so far as quality is concerned, finds its way to Ruelle, for, although a large proportion of the metal run for the manufacture of cannon consists of pigs made from the ore on the premises, yet formerly these latter were supplied by the neighbouring furnaces, Jaumellières, Chapelle, and La Motte. Recently some importations have been made from Alélick, in Algeria, of grey pig-iron, possessing an extraordinary degree of tenacity and toughness. These qualities are indispensable, since all white, hard, and brittle iron would give very bad results. The contractors despatch the pigs, having a weight of four hundredweight, to the foundry, where they are broken, and the nature and appearance of the fracture at once determines their acceptance or rejection. Those which pass this preliminary inspection are further tested by being employed in the casting of a cannon which is subsequently proved *á outrance*. To ensure the iron admitted to the premises possessing the qualities required, 55 per cent. of it is fused along with the quantum necessary for running a cannon of certain dimensions. The cannon being cast, it is subjected to the following proofs:—The first trial is made with one shot and a charge of two and three-quarter pounds of powder, fired twenty times in succession; the next with two balls, and a charge of four pounds and a half of powder, fired the same number of times; and the third with three balls and the same charge of powder, fired ten times consecutively. After withstanding this test it is further proved by being fired five times with six balls and a charge of nearly nine pounds of powder, and subsequently with a charge of fifteen pounds and a half of powder, and thirteen balls fired the same number of times.* This

* "The proof of the Armstrong guns is two rounds with service charge and shot, and three rounds with service shot and a charge of one-sixth of the weight of the shot."—*The Engineer.*

last test is repeated ten times, and if the piece stands it without evincing any symptoms of weakness the iron is accepted, but if it should give way during the trial the iron tendered is not merely rejected, but the tenderer is obliged by his agreement to defray the cost of testing.

After the ore has been examined and accepted it is spread out upon the ground, and the earth and residue of the matrix adhering to it carefully separated; and to effect this operation in the most complete manner, every lump bigger than a nut is broken in pieces. It is then allowed to remain exposed to the air for a time long enough to permit the small traces of sulphur to be dissipated, and the combined influences of the air and rain remove nearly all vestiges of any magnesia that may be present. This process is termed maceration; and although in order to carry it out it is necessary to have always a large stock of ore on hand, yet it is considered so important a measure that the former condition is unhesitatingly complied with by the managers of the establishment. The maceration accomplished, the mineral is washed in circular troughs, through which a stream of water continually passes, and in which paddles fixed upon a vertical shaft maintain an incessant agitation. By these means all foreign substances not yet detached from the ore, are effectually removed. It is subsequently dried and piled up in heaps, consisting of horizontal layers of a certain thickness, which are cut through vertically when the waggon comes for a supply for the blast furnaces. An average quality of all the iron obtained from the different mines is thus made use of, as the layers, fourteen in number, composing the heap are arranged so that no two successive should consist of iron brought from the same locality.

The manner of charging the furnaces at Ruelle is very simple. An inclined plane, with rails laid down upon it, carries a small truck which is drawn up the incline by an endless chain worked by one of the water-wheels on the premises. Alternately with the ore, charges of charcoal and castina are tipped into the furnace. Nine men constitute the working staff attached to each furnace, of which five are entrusted with everything connected with the charging; two of the above number have the care of the blast and the pipes; one performs the duty of clearing away the cinders

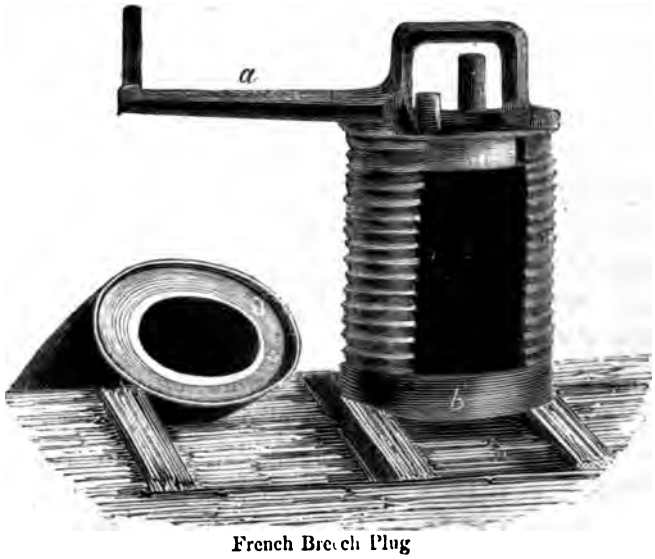
and ashes, and another prepares the moulds for the running of the metal. These operations are carried on night and day, and a special dormitory in the vincinity of the furnaces is appropriated to the use of the men who have charge of them. The process is always conducted with the view of obtaining pigs more or less grey and spotted; and one of the means of ascertaining outside what is transpiring inside the furnace is by a careful inspection and examination of the dross or scories. The results of the inspection are both curious and interesting, especially to metallurgists. The colors of the scories present, at different stages of the melting, almost all the varied hues of the rainbow, but those generally observed are violet, bright green, neutral and deep green, inclining to black occasionally. A persistent violet tinge is a sign of a greyish flocky metal, and distinguishes the commencement of the fusion; this is a defect, and probably arises from an insufficient amount of blast power. When the tint is bright green, a clear grey iron is the result, and when it passes to a neutral or deep shade, or preserves that shade for some time, the produce of the furnace has a spotted appearance. The presence of a very dark green approaching to a black hue is a certain indication that the pig will be white. By altering the proportions of ore and castina, or by modifying the blast, the colors of the scories can be changed at pleasure; but previously to adopting any regular and fixed method, the results of the former running are carefully examined, in order to be certain that harm, instead of good, might not arise from any fresh interference. The pigs produced in the blast-furnaces on the premises are, similarly to those purchased elsewhere, broken up, carefully examined, and classed according as they present a lighter or darker color and varieties in the nature and appearance of the fracture. These home-made pigs, so to term them, constitute forty per cent. of the different mixtures used in casting; twenty per cent. is supplied by pigs of a second melting, and the remaining proportion by those obtained from the neighbouring workshops. A scrupulous attention is paid to the exactitude of these proportions; only assistants of great experience and judgment are allowed to examine the qualities of the respective pigs, to class them, and to superintend the operation of depositing them, in separate charges, near the opening of the furnaces ready for instant injection.

Coal is the combustible employed in heating the furnaces, the flame of which runs along the ceiling and passes over the pigs, which are so arranged that the largest receives the greatest amount of heat. At Ruelle the practice is to carry on the heating very rapidly and energetically, so as to effect the fusion with the greatest possible despatch. One advantage of this method of proceeding is that the metal is endowed with an extreme fluidity, and all the scories is disengaged and floats upon the surface; moreover, it takes a longer time to cool, and its tenacity is thereby considerably augmented. About two hours is the time usually occupied by one melting.

The French cannon, like our own, are cast upon the core system. Solid cores of iron are used prepared with moulding sand and loam in the usual manner. As the cannons cast at Ruelle are all breech-loaders and hooped, the difficulties formerly attending the preparation of the breech and trunnion moulds, are obviated. The moulds finally being in position are connected at the bottom, and at different points in their height, with the channels leading from the furnaces, by means of iron pipes coated in the inside with fire-clay. The metal enters the mould by the lowest orifice, and rising within it, carries the scories upon the surface, which again is raised higher by the arrival of the metal at the next orifice. A registry of the exact time during which the operation lasts, and the manner in which each furnace contributes to the general running, is carefully noted so as to serve for reference on future occasions. For some time past the method of casting the cannons at Ruelle with the breech downwards has been discontinued, since it is now generally admitted that the densest part of a long cast-iron cylinder is not, as would naturally be supposed, at the end occupying the lowest position in the mould, and consequently supporting the weight of the superincumbent fluid, but at a point somewhere about the middle of the length. This statement has been confirmed by experiments made in Sweden.

The French naval guns consist, chiefly, of four sizes, viz: 6½-inch, 7½-inch, 9½-inch, and 10¾-inch. The latter has not, as yet, been generally adopted in the service. These cannon are not of one homo-

geneous metal, like Krupp's, or the largest American guns, but consist of a core of cast-iron with a re-inforce of steel hoops. They are all rifled breech-loaders. At first only a single series of rings was put on, but it was found that notwithstanding every effort to hide the joints, they invariably opened, after a certain number of rounds in quick succession had been fired. The present plan is to put on a double series of steel rings, one over the other, so as to break joint. These rings are made of puddled steel, and are chiefly supplied by MM. Petin, and Gaudet of St. Chamond. Their thickness varies from two to four inches, according to the calibre of the gun. The breech is closed by a screw of fifteen or sixteen threads, cut into the metal of the gun, into which is screwed a plug of steel. Were it necessary in firing to screw and unscrew the whole length of this plug at every round, much time would be wasted. This difficulty is obviated by the invention of an American, Mr. Eastman which will be better understood by referring to the accompanying woodcut. This screw, or breech plug, is a



French Breech Plug

cylinder of cast-steel, upon the surface of which threads have been cut. The screw is then divided into six equal parts, in three of which the threads are removed, both from the plug and the breech

of the gun. When the breech is to be closed, the threaded portions of the plug are presented, so that they come opposite the smooth parts of the hole, and *vice versâ*. The stopper is then pushed in, when a third of a turn with the handle *a*, brings the screws of both parts together. It is evident, however, that this operation could never produce and maintain a gas-tight joint, so the front of the plug is furnished with a ring *b*, capable of revolving freely on its axis, and to which is attached a cup, or Broadwell ring, which is composed of the softest description of steel. The elasticity of this ring permits its flange to expand and be compressed against the bore of the gun, thus preventing the escape of gas. These rings, or cups, which sustain the first and worst of the shock, are often placed *hors de combat*, but they are easily renewed. The weight of the breech-plug for a 9½-inch gun is about 500 lbs., consequently some arrangement had to be devised for the purpose of supporting and guiding it. The mechanism consists of a bronze frame, attached, or rather hinged, to the side of the breech of the gun, in contiguity to the opening. This frame carries a bracket, which has a kind of gutter, in which slides the screw portion of the plug. When the frame is swung back to the right, it carries the plug or stopper (previously drawn out of the breech) clear of the opening in the rear of the gun. To facilitate the introduction of the shot, weighing for a 9½-inch gun 320 lbs., a small iron platform or tray is attached to the underside of the breech, and by this arrangement the envelopes of the cartridges are prevented from being torn by the threads of the screw. The platform is constructed with a groove intended to guide the shot in the right direction, and is sufficiently long to allow both shot and cartridge to pass, not only the threads of the tapped portion of the breech, but also the part where the plug and the powder are placed. In the older plan the iron tray was fixed to the bracket, but in the hinge system it is independent of the rest of the apparatus, and is run in and out by hand.

The French authorities, and their exponents, whose descriptions in "*Les Grandes Usines*" we have partly adopted, consider the above method of closing the breech, superior to the block or wedge system of Krupp. The sides of the breech are not

weakened as in Krupp's guns, but, on the other hand, the through block or wedge of the latter is better calculated to inspire confidence than a shallow screw thread cut in cast iron. There is also the danger of this screw being left unturned, or only partially turned.

"This neglect," says our authority (as translated in the London *Mechanics' Magazine*), "occurred on board the 'Montebello,' and the results, as can be readily imagined, were both serious and fatal. It was at first supposed that the stopper had been properly inserted and screwed up, and that the accident was due to the violence of the charge, which had proved itself too strong for the holding power of the screw, and it is needless to say that those who had served the gun persevered in this opinion. But, unfortunately for their veracity, a series of experiments was at once undertaken to test the fact and determine the resistance of the threads. After every discharge the stopper was turned a fraction of a revolution, and it was unmistakably demonstrated that the explosion produced not the slightest effect upon the position of the screw. The smallest catch or bite of the screw was sufficient to resist the shock of the discharge."

This semi-official statement, however, being at variance with well-known mechanical laws, as well as with the results of the experiments made elsewhere, must be taken *cum grano.* It may perhaps be excusable in the French authorities, after an accident like that on board the "Montebello," to endeavour, by a pious fraud, to restore among their own men full confidence in their guns, but those who know anything of the difficulties of securing the breech of heavy cannon, will be chary in believing, that the "*smallest catch, or bite,*" of a screw *already half cut away*, was sufficient to resist the shock of a discharge of fifty-five pounds of powder, behind a shot of 320lbs. in weight. Though the authorities appeared satisfied that the manner of closing the breech was not defective or dangerous, the "Montebello" accident clearly showed that some precaution was indispensable to prevent a similar occurrence taking place, and that the possibility of so serious a contingency must not be left in the hands of the gunners. To obviate the danger resulting from a neglect to screw up the stopper, when it was in its place and the breech closed, the following arrangement was employed:—The

lanyard, or firing string, is caused to pass through the eye of a piece of iron fixed upon the breech, and carries a bob upon it. When the handle is not in its place, that is, when the stopper is not safely screwed in, a spring closes the eye and will not allow the bob to pass, and as the length of the string is so adjusted that in this position it cannot fire the gun, all danger is prevented. When, however, the handle is in its proper position, it acts upon the spring which opens the eye, and allows the bob to pass, and affords a sufficient length of string to fire the gun.

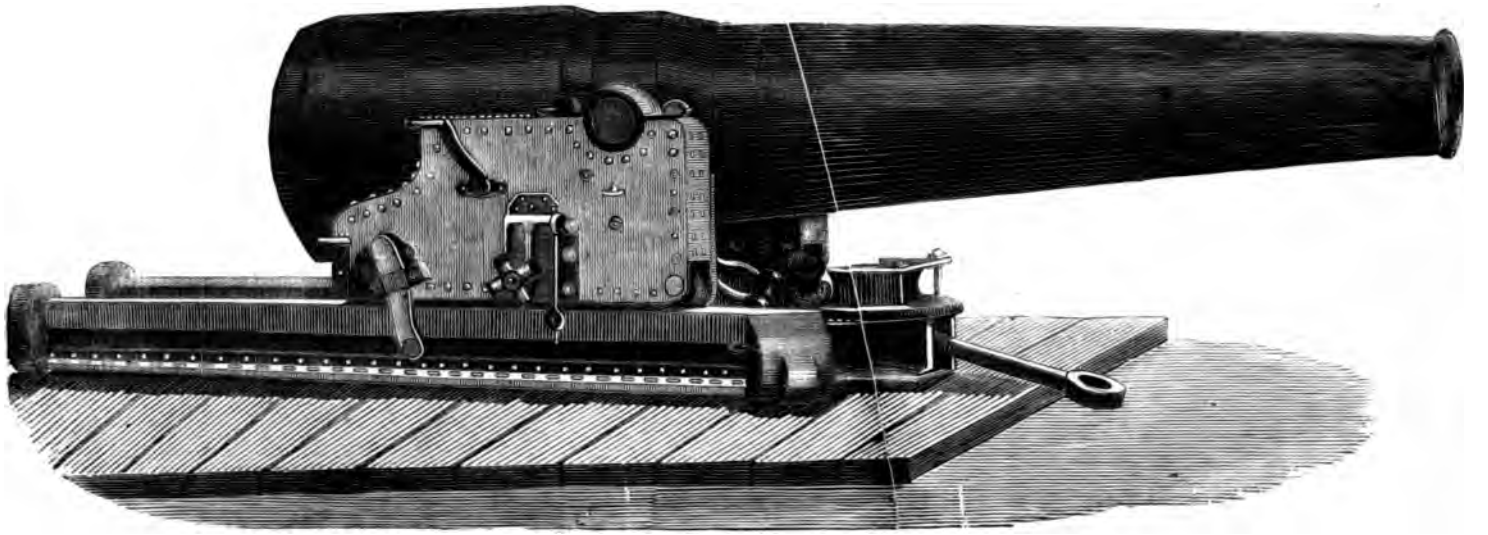
Our next woodcut represents the 9½-inch gun, and as the others are similar in their proportions, it will give an idea of the form and outline of each calibre.

The following table of details of their relative dimensions from an official source will supplement the sketch.

Gun.	Length.	Diameter at Breech.	Weight.
6½ inch.	11.54 feet.	2.11 feet.	11.200 lbs.
7½ inch.	12.51 feet.	2.57 feet.	17.900 lbs.
9½ inch.	14.95 feet.	3.27 feet.	30.800 lbs.
10½ inch.	15.82 feet.	3.72 feet.	48.100 lbs.

The 6½-inch gun is rifled with three parabolic grooves, their inclination varying throughout the length of the piece: near the breech it is zero, and it gradually increases towards the muzzle, where it acquires a maximum of six degrees. The 7½-inch and 9½-inch guns have the same twist as the 6½-inch, but with five grooves. With a charge of powder weighing eleven pounds, and an oblong cast-iron shot seventy pounds in weight, the range of the 6½-inch gun varies with the angle of elevation as follows:—

With an angle of 2 deg. the range is 1,040 yards; with an angle of 10 deg. 3,500 yards; and with an angle of 35 deg. it reaches 5,000 yards. The lateral deviation of the projectile at the last-mentioned range is 32ft., and the average longitudinal deviation amounts to 144ft. Besides the above results, others are obtained with a charge of 14lbs. of powder, and by the employment of a different projectile. With this second charge a solid steel shot is used, weighing almost exactly 100lbs., and having either a cylindrical or ogival-cylindrical shape. The range of this projectile



French 9½-inch **Naval Gun.**

at an elevation of 4 deg. gives an average of 1,870 yards, or rather over a mile.

With a charge of 17½ pounds of powder and a cast-iron shot weighing 115 pounds, and with elevations of 2°, 10°, and 35°, the ranges of the 7½-inch gun are respectively 1,000 yards 3,640 yards, and 7,700 yards. A maximum lateral deviation of 45ft. is produced by the last range, and the longitudinal deviation, taking the mean, equals 140ft. Increasing the charge to about 28lb., and using a solid shot of the original shape weighing 165lb., produces no particular effect within a range of 1,000 yards from that already afforded by the elongated projectile.

A charge of thirty-six pounds of powder, and a cast-iron oblong shot weighing on the average 220 pounds, and with the same elevation as before, gave the separate ranges of the 9½-inch gun, as 1,100 yards, 4,000 yards, and 8,600 yards. The second charge consisted of forty-five pounds of powder, and a solid steel ogival-cylindrical projectile, weighing about 320 pounds. With an elevation of three degrees, the latter projectile carried 1,230 yards, and the former just 100 yards less. No accurate results of the firing of the 10¾-inch gun have yet been recorded.

The gun-carriage of the nine-and-a-half-inch naval gun—as well as of the other calibres—is of wrought iron, and rests upon a frame, also of that metal, and which is attached to the side of the vessel by a bolt; it rests upon small rollers, provided with studs, between which levers can be introduced for the purpose of slewing the gun laterally. Underneath the part of the gun lying in the carriage are fixed cross-ties, furnished with strong springs for the purpose of diminishing the violence of the shock and the strain upon the cordage. The holding tackle passes round a pulley fixed upon the front part of the frame and is also connected to the cross-ties. These cross-ties are formed with a curve in their centre part to clear the lower portion of the breech of the gun. To elevate the muzzle of the piece, there is a chain passing round a wheel inside each of the boxes forming the upright carriage. An endless chain, worked by a crank handle, sets this

wheel in motion, and raises or lowers the gun at pleasure In order to diminish and retard the recoil, each side of the carriage is provided with a brake clasping the corresponding side of the frame. The breadth of the sides of the frame upon which the brakes act is increased gradually as the piece recoils, and consequently the friction increases as the velocity of the recoil diminishes, so that the resistance to the force developed by the discharge upon the carriage is always approaching to a maximum, while the force itself on the contrary is in a continually decreasing ratio. Together, the carriage and frame weigh about six and a quarter tons, thus making the total weight of carriage and gun equal to twenty tons.

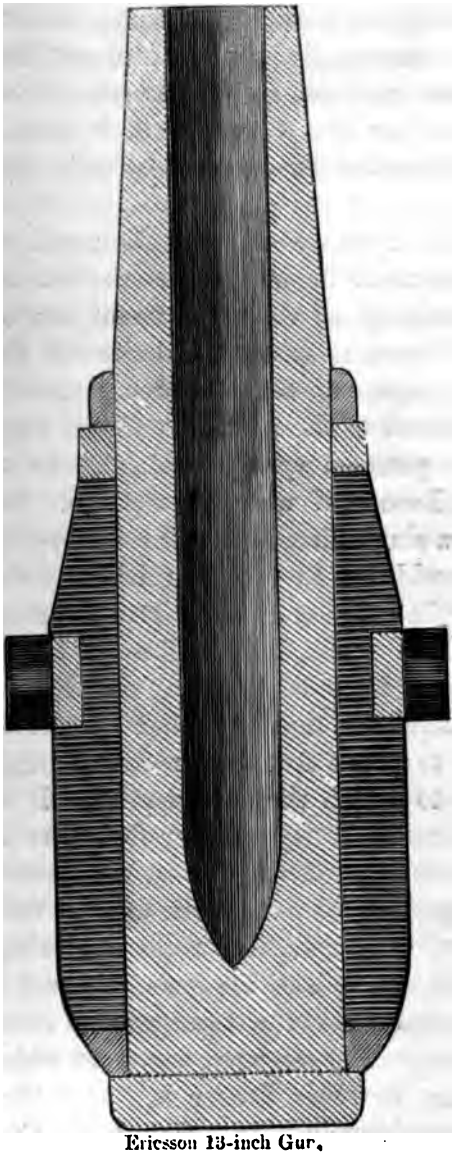
Close to, and towering above, the guns we have just been describing, is a smooth-bore cannon. This gun is constructed on the same principles as the others, with steel re-inforce rings, and the same breech-closing arrangement. It is eighteen feet long, sixteen and-a-half-inch bore, and weighs about 85,000 pounds. It has a breech preponderance of 1,300 pounds. The diameter of the shot is sixteen-and-three-eight inches, it weighs about 650 pounds, and is fired with a charge of 110 pounds of powder. This gun, which is the first and only one of its size in France, has not yet been proved, further than to fire a couple of rounds with ordinary charges.

The three most noticeable points about these French guns are, —first, the care bestowed on the selection of the materials for their manufacture; second, the re-inforce breech-rings; and third, the breech-closing arrangement. In regard to the first, there can be little doubt, that whatever may be the intrinsic value of the ores from which these guns are made, as compared with those of our own, and other countries, the French guns will possess a uniformity of texture and strength, which cannot be expected from the productions of private firms. We have noticed the severe tests to which all the iron admitted to the arsenal at Ruelle, is subjected. This, and the subsequent treatment and mixture of the different ores, argue the existence of authority and system rarely met with outside of military establishments. There is no ack of instances to prove, that without a rigid Government

inspection, the cannon of private firms will deteriorate according to the state of the market, and other circumstances bearing on demand and the means of production. The Swedish cannon founders, at one time, had almost a monopoly of the cannon trade of Europe, and the demands upon them were so great, that the usual care in the selection of ores, was relaxed; the guns fell off in quality and reliability, and consequently, the trade almost left Sweden. This sharp lesson was not lost on the Swedes, for at Finspong, where the ordnance for the Government is manufactured, the selection and treatment of the ores are as rigid and scientific as at Ruelle.

With reference to the second feature,—though the metal of which the French naval guns are made be as good as the attainable ores, and the present knowledge of their treatment can be expected to produce, it does not seem to satisfy the desires of the Government, as the universal system of re-inforcing clearly indicates. We have before referred to the re-inforce of steel-rings applied to the breech of these guns—a system which seems to prevail extensively throughout Europe, if we may judge from the number of rings supplied by a single firm before the commencement of the present year. In addition to those furnished to the French Government, Messrs. Petin and Gaudet have supplied rings for 800 cannon to Italy, 500 to Spain, 130 to Russia, 180 to Denmark, twenty-five to Turkey, forty to Sweden, and 120 to England. We are not aware, however, that any reliable series of experiments have been made to prove that these re-inforce rings really do strengthen the guns to which they are applied. If, as Professor Barlow alleges, "the metal in any cylinder decreases in utility in proportion to the square of its distance from the centre, and therefore the outside of a gun of the form now used is only one-ninth as useful as the inside," it follows, that these steel rings add but little, if anything, to the strength of the guns. Indeed, it is doubtful if they really compensate for the homogeneous metal cut away to make place for them. The strongest argument which the advocates of re-inforcing use in their favour is, "that they prevent the gun from bursting explosively," in other words they "save the pieces." But if this be their only use, surely steel is

neither the best nor the cheapest material; a soft wrought iron re-inforce would be preferable, and perhaps the system adopted in Ericsson's thirteen-inch gun would be the best. The barrel of this gun is strengthened by forcing over it washers of wrought iron, by hydraulic pressure. The core or solid part of the gun is thus put into compression, while the washers are put into extension. The cone has longitudinal fibre only, being welded up from bars. Ericsson guarantees that this gun will stand 100lb. charges.



Ericsson 13-inch Gun.

Without dwelling on a point which can only be satisfactorily settled by a long and expensive course of experiments, we come to the third, and most distinctive feature of these French guns, namely, the breech-closing arrangement.

This, though an American invention, has not given such satisfaction with us, as to lead to its adoption. Indeed, the idea of effectually closing the breech in this way has been long ago disdiscarded in America. We have already referred to the blowing out of the breech of a gun on board the Montebello, and the experiments entered into in consequence,

to test the reliability of the officially adopted system of breech-closing. But these experiments, like all the French naval and military tests, generally prove too much. We hear one day of some *trial* at Toulon that demonstrates how speedily the best protected ironclad can be destroyed; and then it is some small cannon (a profound secret of course), that can sweep away a whole battalion at a single discharge. In the present case, in order to show the impossibility of the breech-screw proving unfaithful, the official report says:— "After every discharge the stopper was turned a *fraction* of a revolution, and it was unmistakably demonstrated that the explosion produced not the slightest effect upon the position of the screw;" and lest there should be any doubt as to the meaning of the word "fraction," it is added, "the *smallest catch* or *bite* of the screw was sufficient to resist the shock of the discharge." This is just the case with all these French experiments which are made public, a certain result is given but the particulars are kept back; how easy it would have been to have given, in *centimètres*, the exact size of the "smallest catch or bite." With the manufacturers of heavy guns all the world over, this one point of getting the breech to stand is the great desideratum. To obtain sufficient strength for that point, in a huge war-engine from which a heavy body is projected instanter, at a great velocity with a force of 4,000 or 5,000 foot-tons, has been a matter of anxious study to all mechanicians who have dealt with the question; but to the French artillerist it gives no trouble, "the smallest catch or bite" of his half cut away screw is quite sufficient.

Leaving these assurances of strength to those who may be pleased to accept them, we may observe that the life of the screw in the breech of this gun will determine the life of the gun itself. Should this cast-iron screw strip, which is not unlikely, it could only be replaced by boring out the breech for the insertion of a steel or iron screw to receive the breech plug, a proceeding which would considerably weaken the breech, by multiplying the parts composing it, and by reducing the sectional area of the gun itself at the point where the inserted screw-piece terminated. The one advantage of the French screw, or rather half-screw, plug, is that the sides of the breech are not cut away, as in the English and

German breech-loaders, for the insertion of wedges, bolts, and vent-pieces. But it is doubtful if this one advantage will compensate for the obvious and inherent weakness and uncertainty of the French system.

Standing by the jealously-guarded enclosure in which the French guns are exhibited, one frequently observes the intelligent artillery-man or gunner in charge, making slight mistakes in pushing home and adjusting the screw-plug. The smallest surplus force applied in this operation will make the plug recoil enough to bring the square cut ends of the threads opposite, when the plug will not of course answer to the lever, until an additional push has been given to it, and sometimes it is necessary to draw it out again, and return it with a force more nicely adjusted. If, in action, apart from the effects of a moderate sea, the plug should receive from some less experienced hand a push strong enough to make it recoil the breath of one thread, or if the shot and charge were not pushed sufficiently forward, the threads of plug and gun might correspond and the lever be pulled round leaving the breech improperly closed, with consequences that may be easily conceived. Again, the opening of the breech of a gun of nine and a half-inch bore, and fifteen feet long, especially after firing to windward, would be followed by a cloud of smoke, that, for a time, would greatly retard re-loading and sighting, and possibly lead to serious local accidents, which, in battle, have a greater tendency to demoralize the men than even the shot of the enemy.

Besides the above evils there is another disadvantage (common to all breech-loading cannon of large calibre) arising from the necessity of handling, at every round, two heavy masses of iron instead of one.

A comparison between the large French smooth-bore cannon. and the Rodman gun recently tried in England, shows the weight of the former to be 85,000lbs. and the latter 43,000lbs. or only about one-half the weight of the French gun. Now with due allowance for the $1\frac{1}{2}$-inch difference in calibre (the French gun being $16\frac{1}{2}$-inch bore) and the breech arrangement, the French gun is either too heavy or the American too light; supposing the former to be of the same calibre as the latter, and say we deduct 14,000 lbs.

for the extra weight required to carry the breech apparatus, etc., for the difference in calibre, and 8,000 lbs., then a French smooth-bore gun of fifteen-inch calibre would weigh 63,000lbs., or 20,000 lbs., more than the Rodman fifteen-inch gun. Perhaps the medium — 53,000 lbs. — would be a proper weight for a gun of this calibre. With this weight of the superior iron, which abounds in the United states, and perhaps a judicious admixture of some of the best Canadian ores, guns of large calibre could be produced, which would stand much heavier charges than those used at present. In 1862, a pair of cast-iron railroad wheels were exhibited in London (made from Canadian bog-iron ore) which had run 125,000 miles on the Grand Trunk Railroad, under the Post-Office car, and seemed to be nothing the worse for wear. A portion of this ore, which produces iron of great toughness, mixed with some of our best ores, all selected and treated with the care betowed on the manufacture of French cannon, could not fail to produce guns of unequalled excellence. If, with a charge of sixty-pounds of powder, the fifteen-inch gun gives a velocity of 1,320 feet per second to a shot of 440lbs. weight, it would give a velocity of not less than 1,600 feet to the same shot, if the charge could be increased to 110lbs., or one-fourth of the weight of the shot.*

Before abandoning the reflections raised by the large French smooth-bore, and resuming our review of the heavy ordnance scattered over the Champ de Mars, it may be well, briefly, to notice the recent trial of the Rodman gun at Shoeburyness, and its effect on the English press. The *Standard* referring to the trial for range and accuracy says: "Fifteen rounds altogether were fired, and sufficed to give a valuable character to the weapon. The practice on such occasions as the present is to train the gun upon some definite object, such as a target, in a nearly horizontal direction—in this case two degrees of elevation taken with a spirit-level quadrant—and then to fire with various charges of powder, noting the spots at which the shots first graze, and the time, in seconds, from the discharge in which they do so. The rest of the flight of the

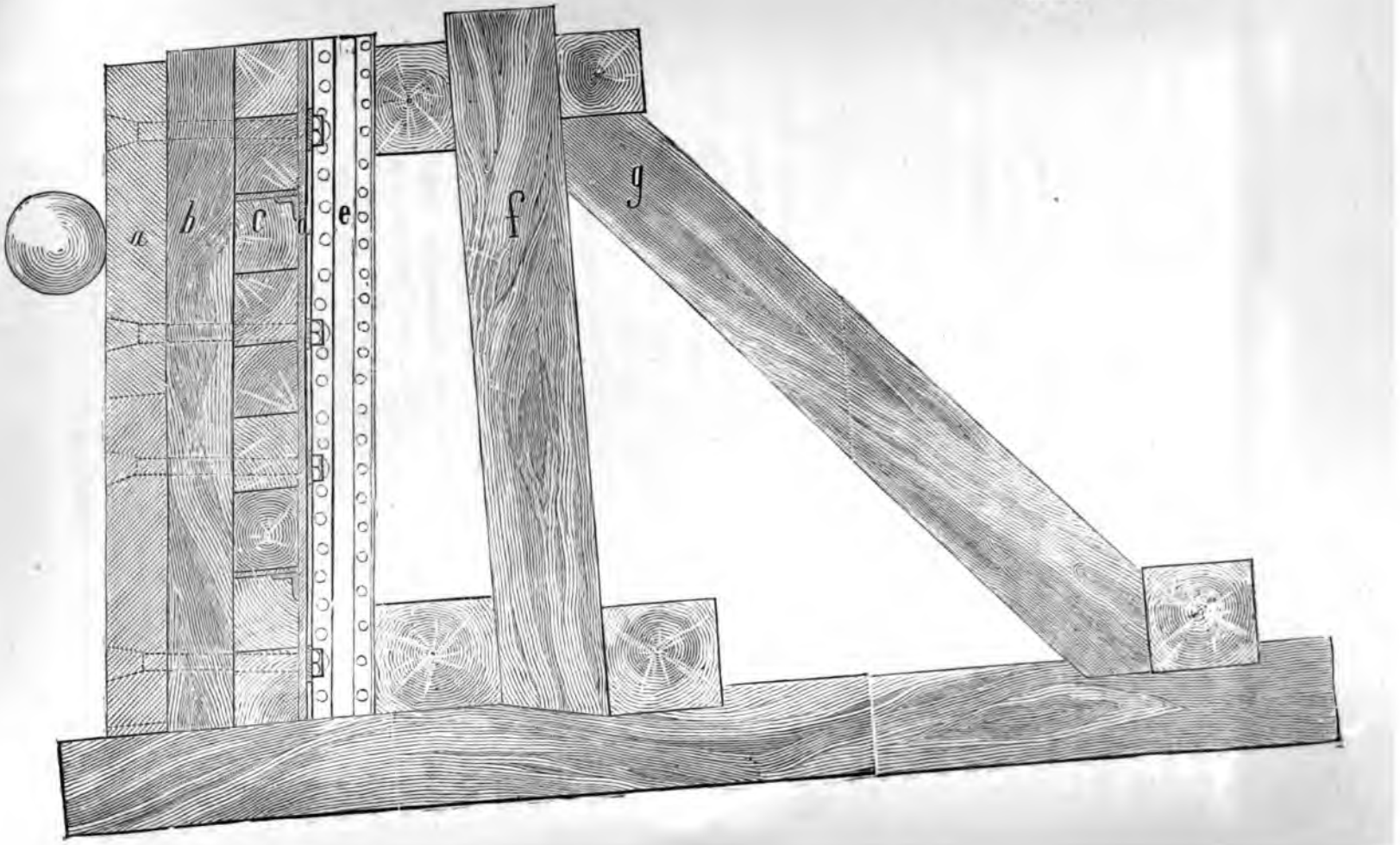
* Since the above was written, this gun, at Shoeburyness, gave a velocity of 1,5 :8 feet, and a range of 7,680 yards, at 32° elevation, with 100lbs. of powder.

missiles in their ricochets, is only incidentally noted. The object is not to hit the target, but to find out the distances certain charges will project shots of the same weight, and the amount of deflection those shots experience and the velocities they attain in their flight." After giving details of the fifteen rounds, the article concludes as follows :—"The American Rodman has thrown its shot very true and a very long distance. It was a pretty sight to see the dark ball rebounding from the mirror-like sea, dashing up a round cloud of spray at each ricochet, until at last, in the far distance, out amongst the grey hazy ships, a faint continuous white mist streaked for many seconds the surface of the water, and the thud, thud of the rebounds of the shot died away in a pulsating noise like the distant puffing of a railway train."

The *Times*, on the other hand, speaks disparagingly of American guns, and says "they look big and threatening, and make a great noise when their shot strikes the outside of a vessel;" and yet, in the same article, comes the reluctant confession that, "though the fifteen-inch shot did not get through the eight-inch plate and backing, it would have penetrated most of our ships." The organ of the Government, the *Standard*, with more candour, and in a fairer spirit, referring to the trial for penetration, says :

The American fifteen-inch Rodman gun was tried yesterday against the eight-inch target at Shoeburyness with so great effect, that it may be said to have proved its capability of penetrating any of our iron-clads afloat. The "Hercules" ought to keep these missiles out but, she is not yet afloat. We do not for one moment intend to indicate any superiority for the American fifteen-inch gun over our own nine-inch, or even, in most cases, our smaller seven-inch guns, whilst Major Palliser has recently demonstrated the way for converting our large stock of sixty-eight-pounders and other cast-iron cannon into really efficient rifled artillery. Nor would we attempt to contend that the heavier missiles of the American guns would have the same penetrative power at long ranges as our own lighter elongated rifle Palliser projectiles thrown at higher velocities. But it is something most essential to know that American 450-pounder smooth bore-guns could certainly hull our iron-cased vessels at 100 yards, and that henceforth no English man-of-war could be laid broadside against an American ship carrying guns of this calibre. In future the ships must be kept at an angle to each other; and hence one would naturally deduce the conclusion that an

Vertical Section, 8-inch Warrior Target,
Scale, ½ in. to 1 foot.



additional reason is thus given in favour of the fighting utility of turret-ships capable of properly training the heaviest guns all but directly fore and aft. Nor must we omit to consider possible contingencies in the application by an enemy of such powerful smooth-bore guns, the shot from which are remarkably accurate in their flight. The fifteen-inch gun now at Shoeburyness is warranted proved, it is true, for only a limited number of battering charges of sixty pounds. But there is no doubt that the gun would fire many rounds of seventy pounds of powder with very little risk. What the effect of ten pounds more powder yesterday might have been is, probably, that the sixty-pound charge, having proved sufficient to crush in the thick armor plates, the extra ten pounds of powder would have carried the projectile completely through the wood backing. Now, the American gun might certainly be fired at a risk with 100 pounds of powder, and there can be very little doubt that if the commander of a ship armed with such guns felt a conviction, as he might do, that he could knock a fifteen-inch hole in the side of a nine or ten-inch armour-clad enemy, that he would run the risk of bursting a gun for the chance of sinking his antagonist.

The foregoing remarks all refer to the first trial of the fifteen-inch gun against the eight-inch Warrior target with sixty pounds charges. But the gun, as suggested by the writer in the *Standard*, has since been fired with 100 pounds charges, at the same target, with results which are more easily imagined than described. We give, in the accompanying woodcut, a sketch of the eight-inch Warrior target on a scale of half-an-inch to the foot, with a fifteen-inch shot impinging on the outer plate. The shot swept clean through the target, carrying before it nearly a ton weight of the armor plate *a*, the eighteen-inch teak backing *b*, *c*, the skin *d*, and the double frames *e*, (twelve inches apart) together with four sets of the massive timber frames *f*, *g*. The ground, far and wide in rear of the target, was thickly strewn with fragments of iron and splinters of timber. In short no such destruction was ever effected at Shoeburyness by any single shot.*

* Before these trials took place, *Engineering*, in speaking of American Ordnance, said,—"It is much to be wished that the real power of the heavy fifteen-inch and twenty-inch guns was understood in this country, instead of our believing so generally in their "low velocities." In the large chambers of these guns the powder gas has additional room for expansion, and, as would be the case with steam cut off at a small portion of the length of a large steam cylinder, it thus

The exception made by the writer in the *Standard* in favor of the "Hercules," is evidently made under a mistaken notion of the thickness of the armor plates of that ship. From statements made in Parliament, by Lord Clarence Paget, when Secretary of the Admiralty, and especially from the fact that a target having a nine-inch plate, and *called* the "Hercules Target" was tried at Shoeburyness, the British public believe that the armor of the "Hercules" is nine inches thick throughout. The armor plates of this vessel, however (as will be seen when we come to speak of iron-clad ships), are, mainly six inches thick, the same as those of the "Bellerophon.". True, there is a narrow belt of armor nine inches in thickness; but it is almost entirely below the water-line, whilst the plates which protect her battery and the hull generally, being only six inches, would be easily penetrated by the fifteen-inch Rodman, at seventy yards, with sixty pounds of powder.

There is one feature, connected with the French rifling, that demands a passing notice, before we take a final leave of this new and untried system of naval ordnance. The increasing twist, of course, will not admit of a shot having a long bearing, and which fits nicely into the grooves. Hence, the French use studs at both ends of the shot. The front studs *only*, give the spin to the shot while the back row of smaller size act merely as a *bearing* to keep the shot centred, if possible. Now, though the two rows of studs fit comfortably enough into the grooves at the breech end where there is no twist, they produce a jamming action at the muzzle, and the back, or smaller studs, are invariably shorn off on leaving the gun. At least, such is the case with several shot that have been fired, and which are shown in the Exhibition. This shearing action takes place just as the shot is leaving the gun, and the

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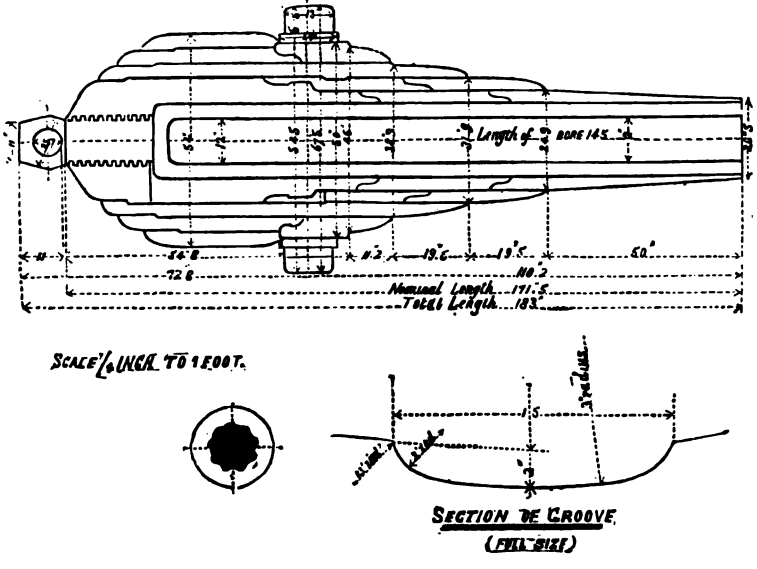
does more work. In reality, while the dynamic value of our cannon powder, for each pound weight, is but about 170,000 foot-pounds, that of no better powder, fired in the large-bore American guns, is 200,000 foot-pounds. Thus, the fifteen-inch gun, fired with sixty pounds of powder and a 440 pound shot, has an initial velocity of 1,320 feet per second, a rate which would certainly not be considered slow by our own ordnance engineers. Our system of small bores and long shot not only strain our guns excessively, but loses us much of the useful effect of our powder."

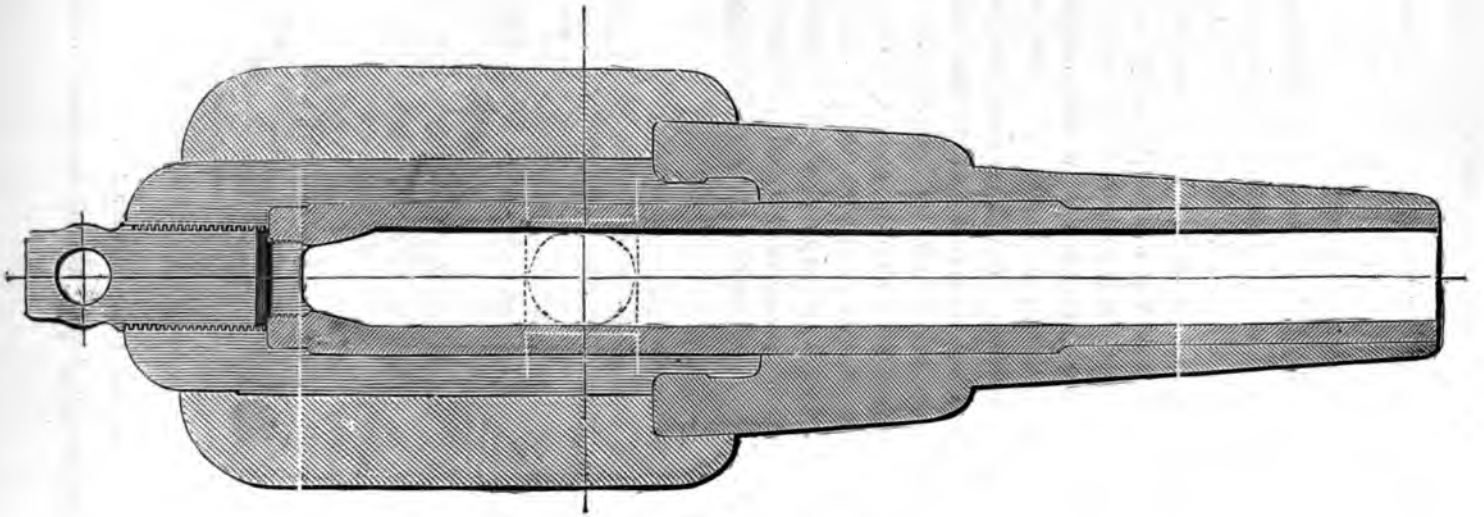
fillip it thus receives frequently gives it a wobbling motion, which cannot fail to be detrimental to its penetrating powers at close quarters, and its accuracy at long ranges.

Though the exhibit of the British Secretary of State for War is certainly the most imposing, comprehensive, and instructive, of all the warlike displays on the Champ de Mars, it is not our intention to speak of it as a whole, but rather to select, under the several heads of our report, those features which properly belong to the question under review, and which serve best to illustrate the progress made in the several branches to which they belong. In "heavy ordnance," there is no collection that can compare in completeness with the British. The Prussians and French both show heavier guns, but in uniformity of system, and detail, the display of Woolwich Arsenal stands unrivalled. At the head of this display of wrought-iron cannon, is a twelve-inch muzzle-loading rifle, said in the official catalogue, to be made on what is now termed the "Woolwich principle;" in other words, the Armstrong system with certain modifications and improvements introduced by Mr. Fraser, the manager of the gun factory; but the gun



Armstrong (Woolwich) 23ton, 12in. gun.

is an Armstrong *pur et simple*, as the annexed woodcut, copied



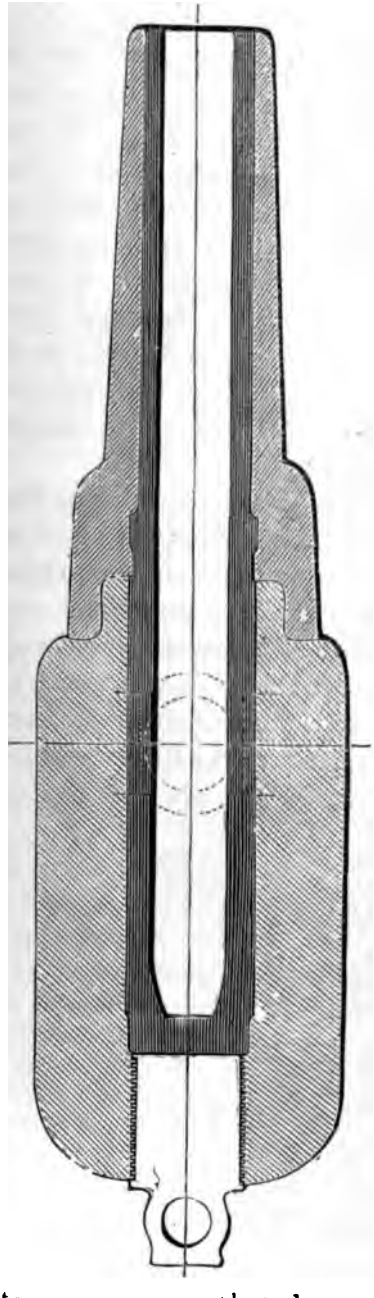
9-inch Fraser Gun with wrought-iron Tube.

from the official catalogue, clearly shows. A comparison between this engraving and the two next in order, will illustrate the steps by which Mr. Fraser is endeavouring to reach homogeneity in the material of the Woolwich guns. Both are built upon the coil system, and the barrels when polished, have the appearance of the twisted barrels of small-arms. The iron used for the several coils, by the different makers, is of the same size, and that used at the Royal Arsenal is a low-priced fibrous iron ranging in price from £7 to £10 per ton. Armstrong makes a spiral coil of this iron, welds it into a cylindrical form, and then turns and finishes each cylinder or part separately, before putting the pieces together. Fraser also makes a spiral coil, but instead of welding or finishing each coil separately, he coils say three spirals in the rough bar on a mandril, or shaft, and then welds the whole together. The foregoing woodcut on a half-inch scale, illustrates one of the latest patterns of Fraser guns made as described.*

That these guns possess greater strength or endurance than the coil guns consisting of many parts, is generally admitted, though none of them have lived long enough as yet, to place the endurance of wrought-iron guns beyond a doubt. After a time these coil guns disappear, one by one, from the experimental grounds at Shoeburyness, and find their way to the ordnance hospital at Woolwich. They seem, as it were, to have some chronic disorder, requiring constant care and skilful treatment. In the larger calibres especially, a gun that has fired 500 rounds is quite a prodigy of

* The peculiar feature of this gun is the conical shape of the chamber alluded to in the following extract from the London *Standard*:—"With the exception of slight scoring, the inner tube of the service construction gun is perfectly sound; that of the Fraser gun shows a small hole in the rear end near the axis, rather more than an inch deep, attributed to the concentration or focussing of the gas, owing the peculiar conical form of the chamber. This form was adopted to lessen the area of the end of the tube directly opposed to the longitudinal strain, and to distribute that strain over a larger total surface; and it is supposed that a modification of the form of the chamber will prevent the possibility of such a fault in other guns; but it is doubtful if the defect is of much importance as it now stands, and it is unlikely that it would have arisen had not the gun been fired not only with heavy charges, but with considerable rapidity (from twenty-five to fifty rounds a day), so as to generate enormous heat, and actually burn the metal at this point."

endurance. There is, however, a tradition of one nine-inch gun having fired 1,000 rounds. After 500 rounds, the soft iron tube was found to be so much scored and worn by the gas, that it was sent back to Woolwich where the vent was plugged up, the gun reversed, and a new vent bored in the opposite side, when it is said to have fired 500 rounds more. The theory of the gradual destruction of these large coiled wrought-iron guns, seems to be as follows :—The heavy discharge of powder heats and expands the inner tube to a great degree before the outer rings, which have no homogeneous connection with the inner, are sufficiently heated to expand and give the inner tube room; consequently the particles of the contiguous surfaces of these tubes are so compressed, that when the firing has ceased and the temperature of the gun returns to its normal state, the outer cylinders or rings having had their particles compressed, do not shrink sufficiently to bear upon the inner tube, which at subsequent firings has to sustain the entire force of the explosion, until it heats and expands so as to get the support of the coils surrounding it. The seam between these coils widens as time wears on, and it is not uncommon to see a gun, that has only been fired forty or fifty times,



Newest 9-inch Fraser Gun with Steel Tube.

in such a state that the blade of a penknife might be inserted between the coils. The Fraser system, by producing a greater degree of homogeneity, has, to some extent, overcome this defect, but whether it is entirely eradicated or not, is a question which time only can decide.* The twelve-inch gun exhibited weighs 52,640lbs. Its length of bore is twelve feet, one inch, and over all it is fourteen feet, three inches and a half. It is rifled with nine grooves, with a spiral increasing from one turn in 1,200 inches, to one turn in 600 inches, or fifty calibres. The elongated projectile used in these guns weighs 600lbs., and the charge of powder is seventy pounds, which gives an initial velocity of 1,200 feet per second. This gun is mounted on a wrought-iron casemate carriage and platform, fitted with Armstrong's self-acting compressor (nine plates, nine feet ten inches long.) The carriage weighs 5,712lbs. and the platform 12,470lbs. which, with the gun, makes a total weight of 70,822lbs. equipped for land service. Several guns of this calibre are also designed for naval service, and the "Captain," a turret-ship building for the Government by Laird Brothers, of Birkenhead, is to have a couple of these twelve-inch guns in each of her two turrets. The British guns, however, chiefly designed for naval service, are the ten-inch eighteen-ton gun; the nine-inch twelve-ton gun, and the seven-inch six and a half-ton gun. The ten-inch gun is not in the Paris Exhibition, but the others are exhibited mounted, and equipped for sea service. The nine-inch gun, of which the opposite woodcut is the latest pattern, weighs 27,014lbs.; the bore is ten

* "One 9-inch gun has now fired 1,043 rounds of which, the last 500 have been with battering charges of forty-three pounds of powder, and shot of 250 pounds weight; while of the proceeding 543 rounds 180 were with battering charges varying from forty to fifty pounds. The upper surface of the bore having suffered considerably from erosion, or scoring, caused by the rush of gas over the projectile during the first 543 rounds, the gun was vented through the original under-side, which then became the upper side; and the last 500 rounds were fired after this change had been made, the original vent being of course plugged up. To prevent this scoring papier-machè wads between the cartridge and projectile, have been introduced with beneficial results. The importance of this result cannot be overestimated, for the scoring consequent upon the windage was the greatest enemy of the steel tube of a muzzle-loader, causing it split to such an extent that the limits of safety for the nine-inch guns were defined as 400 rounds, only 150 of which might be battering charges."—*Standard.*

feet five inches long, and the length over all is twelve feet five inches. It has six grooves, and a spiral of one turn in forty-five calibres. The projectile weighs 250lbs; the battering charge is forty-three pounds, and the service charge thirty pounds, with the respective initial velocities of 1,370 feet and 1,230 feet per second. The gun is mounted on a wrought-iron naval carriage and slide, fitted with Armstrong's compressor, and Scott's running-in-and-out gear. It admits of a maximum elevation of fourteen degrees, and a depression of eight degrees. Neither this nor the twelve-inch gun has any breech preponderance. The seven-inch gun, however, has a breech preponderance of 560 lbs., and weighs altogether 14,504lbs. It has three grooves, a quicker twist—one in thirty-five calibres—and is mounted similarly to the nine-inch gun. The weight of the projectile for the seven-inch gun is 115lbs., the service charge is fourteen pounds, and the battering charge, twenty-two pounds; giving respectively, initial velocities of 1,240 feet, and 1,440 feet per second. A 7-inch breech-loading polygrooved rifled gun on the Armstrong ventpiece system, is also exhibited mounted on a wooden casemate sliding carriage, and wooden traversing platform. This gun is completely equipped for land-service, and its rifling and breech-closing arrangements, are similar to those of the twelve-pounder field gun. A forty-pounder breech-loader mounted on a travelling siege carriage, weighing 7,300 lbs., is also exhibited. Had this exhibition taken place two years ago, perhaps the most interesting gun in the collection, would have been a sixty-four-pounder wrought-iron, muzzle-loading, *shunt*-gun, which now attracts but little attention. The shunt rifling was evidently devised for the better centering of the shot, and perhaps to neutralize the scoring effect produced by the escape of gas over the projectiles, or by the friction of heavy shot on the lower side of the bore of the gun. This is effected by making one half of the groove deep, and the other half shallow. In loading, the shot slides down the deep groove, and at a certain point in the bore of the gun, in coming out, it shunts off to the shallower portion of the groove, thus raising the shot clear of the inner surface of the gun, and placing it fairly in the centre

of the bore as it passes out. This plan of rifling, however, has now been superseded by the increasing twist system of the French ordnance; because the latter seems to give the best results in regard to penetration. To this one quality, all other requisites of ordnance, such as range and accuracy, are being sacrificed by the British authorities.

The British Government collection comprises in all ten pieces of ordnance, besides the guns exhibited by Whitworth, Armstrong, and other private makers. Some of these guns have been mentioned in connection with "Field Ordnance," and others are too well known to require special mention; but before taking leave of these wrought-iron guns, especially the naval guns, a few words require to be said on the system of rifling, and its effects on the utility of the gun as an engine of war.

Visitants at Shoeburyness, before the cheap construction or Fraser guns were made, and before French rifling and Palliser shot formed part and parcel of the British system of ordnance, were generally astonished an the unerring accuracy of the firing.* The white paint bulls'-eye, about the size of the shot to be fired, was generally struck fair in the centre at 200 yards' range, leaving often an annular ring of paint around the hole or indentation made by the shot. The improvements referred to, having, as stated, only penetration in view, have changed all that, and now that the testing range is reduced to seventy yards, the firing is greatly inferior in accuracy, to what it formerly was at 200 yards. The following is a table of the radial deviation of a dozen rounds of the Woolwich guns, with Palliser shot, fired in September last, (1866) at 200 yards' range. The deviation is protracted to 800 yards. The target was forty by nine feet, with twenty feet inclined away thirty degrees, making visual length from guns, thirty-two feet.

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* At the target trials in 1862-3 the accuracy of the firing often attracted the special attention of the representatives of the press, one of whom says—"The general precision of the firing for the day was remarkable, and in some instances, and those in quick succession, the practice was quite astonishing, The bull's-eye was marked each time with a brush and white paint, and the circular patch never exceeded nine inches in diameter. Frequently the shot was made to strike in the very centre of this spot, leaving an annulus or ring around the point of impact."

Nature of Gun.	No. of Round.	"Deviation" as measured at 200 yards.	"Deviation" as projected to 200 yards.
12-ton 9-inch	7th	"Bad" Miss	—
"	8th	"Bad" All but miss	—
"	9th	2ft. 6in.	10ft. 0in.
"	10th	1ft. 2in.	4ft. 8in.
"	11th	1ft. 6in.	6ft. 0in.
"	12th	1ft. 2in.	4ft. 8in.
"	13th	1ft. 11in.	7ft. 8in.
"	14th	1ft. 4in.	5ft. 4in.
"	15th	2ft. 2in.	8ft. 8in.
"	16th	4ft. 7in.	18ft. 4in.
"	17th	1ft. 7in.	6ft. 4in.
9-ton 8-inch	24th	2ft. 6in.	10ft. 6in.
"	25th	1ft. 0in.	4ft. 0in.
6½-ton 7-inch.	—	2ft. 0in.	8ft. 0in.

It should be borne in mind, that this firing was from a fixed battery, at a fixed target, and that the guns were laid by the late Lieutenant Reeves, of the Royal Artillery, who was perhaps one of the best marksmen in England, if not in Europe. We may remark, *en passant*, that it seems very strange that these shot, notwithstanding their greater velocity, have often less penetrating power at seventy yards than at 200 yards. This may be due, in some measure, to the wobbling motion supposed to be given to the shot by the peculiar rifling, and the stud arrangement, which imparts the spin to the shot. It is supposed that the shot loses this eccentric motion as it travels onward, just as a top acquires a steadier spin, a second or two after being freed from the string that sets it in motion. Hence, it is believed that at 200 yards the Palliser shot has lost the swaying flight given it by the fillip which the *rear* studs receive on leaving the gun. (The British, unlike the French, make the *rear* studs take the grooves and guide the shot.) As in the case of the top, the swaying motion revives as the power in the projectile diminishes, these shot, from the insufficient twist given to the rifling, would probably *turn over* at comparatively short ranges. There has been no comparative trial, such as the Armstrong and Whitworth, yet made of the range and accuracy of these Woolwich guns and Palliser shot. When, to the above record of indifferent firing, we add the facts that these naval guns are to be mounted on such unsteady platforms as the English iron-clads, which are notoriously *crank* ships;

that they are destined to fire at moveable objects, and that the ricochet of rifled guns generally goes for nothing, their chances of hitting an enemy's ship in a naval action are very remote. That they can in no case be certain of hitting the spot aimed at, even under the most favorable circumstances, has been clearly proved. Therefore, instead of using the superior speed claimed for British iron-clads, so as to choose their position or distance in action, these ships will be compelled to come to close quarters, or retire altogether. The former alternative, against vessels of the Monitor type armed with big smooth-bores, would to partially-protected ships of the "Warrior," or "Bellerophon," class, be certain destruction, or indeed (as the late experiment at Shoeburyness prove) to any British iron-clad afloat. These matters will be more fully noticed under the head of iron-clad ships, but it is impossible not to be impressed with the unwisdom—the strange fatuity—which is compelling the British and French Governments to trust to rifled guns alone for their naval armaments; thus, as it were, putting all their eggs into one basket. True, one British ship, the "Royal Sovereign," is armed with ten-inch smooth-bores, but for this superior armament she is indebted less to a friendly feeling on the part of the authorities, than to the belief that by refusing to give her rifled guns, they were evincing their disapproval of the vessel as a sea-going ship, and of the turret principle on which she is constructed. Two years ago, these nations had, in the "Kearsage," and "Alabama" engagement,* an eminently practical lesson of the relative value of smooth-bore and rifled guns. But all sorts of

* Since the above was written the following paragraph appeared in the columns of the London *Standard*, one of the organs of the present Government in England. It shows that since the trial of the Rodman gun at Shoeburyness, American gunnery is beginning to be better understood and appreciated:—

"During the wars of 1793-1815 our ships were for the most part armed with two different sorts of guns, the long gun and the carronade; the first, of moderate bore, being for range, and the latter, with large bore and short length, for close quarters. Now our rifled guns possess great range, great accuracy, and great penetration, but small diameter; while the American guns possess great shattering power, the advantage of ricochet when required, and are made at a moderate expense. Would it not be a wise step to arm our ships with some of each sort? If an enemy's side was penetrated by the rifled shot and then struck near a

excuses were invented to favor the vanquished, the practical lesson was thrown away, and those derived from firing at seventy yards' ranges at Shoeburyness, and twenty metre ranges at Vincennes, were taken in preference. The true sailor, as if by instinct, takes to smooth-bore guns and round shot, as more congenial to the element on which he lives and fights than rifled cannon and studded projectiles. So the common sense of experienced naval officers, is a safer guide in matters connected with naval gunnery than the opinion of Boards and Ministers, who are fettered by red tape and routine, and often bamboozled by ordnance manufacturers and interminable official reports. During Admiral Farragut's visit to England, the practical seamen at Portsmouth wished him to see some gun practice, but though hundreds of rifled cannons were ready, when the order, "beat to quarters," was given, "they went," says the newspaper report, "to the guns and handled the great 100-pounder smooth-bore Armstrongs with surprising ease and alacrity." The order was given, 'Load with shot,' and in a few seconds the big guns were shotted, pointed, and ready for the order to fire. The American officers went to the quarter deck of the ship to witness the practice. On the word "Fire" being passed the shot was seen to throw up a jet of water in direct line with the target, passing under the canvas itself between the uprights. Several shots were fired at the target 1800 yards distant, and the practice was remarkably good. The third shot ricochetted, going through the centre part of the target." No such result, save by accident, would follow the ricochet of a rifled shot.

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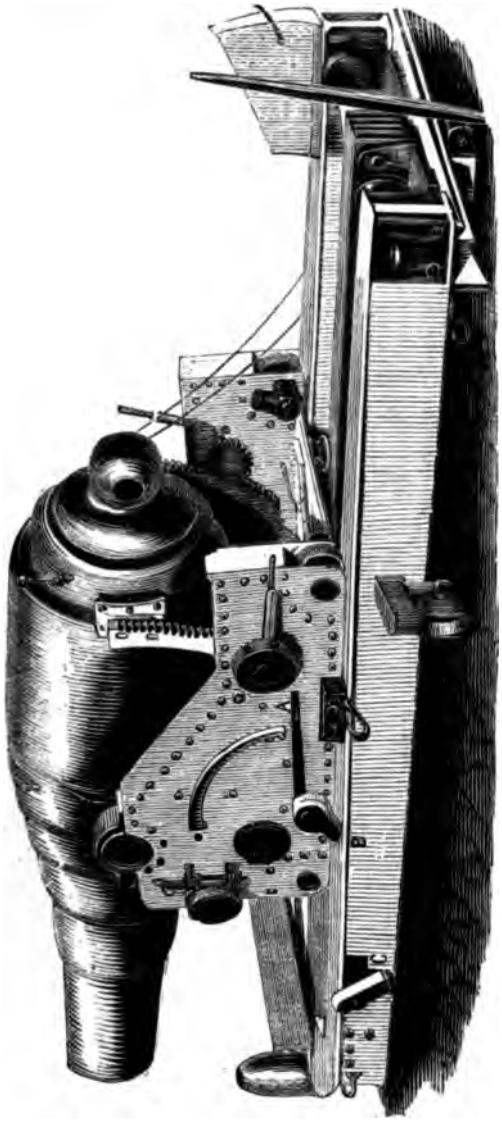
wounded part by a 450-pound ball an awful rent might be made, while rifled bolts would only continue to cut small, clean holes. At all events, against wooden ships and slightly-plated ships, within moderate range, there can be little dispute that large globular balls would be most destructive, as proved in the conflict of the Alabama and Kearsage. The Alabama was armed with rifled and long guns, and the Kearsage with the wide-mouthed Dahlgren guns, which succeeded in tearing such large apertures in her opponent's sides that the latter was soon sunk. There is reason to believe that the chief aim of American gunnery will be not so much to batter an enemy's hull as to sink him by blows between wind and water. Their turret ships are peculiarly favourable to such a system, for the guns are very near the water-level, and the immense round shots are admirable for low ricochet firing."

We have no desire to decry improvements, or to undervalue heavy rifle-guns, they have their sphere of action, which is more properly the casemate of a land fort than the cupola or broadside of a ship of war. One or two such guns might be judiciously used on board ship as chasers, in fine weather. But in a moderate sea, and at medium ranges, the large smooth bore will lay its shot on the water, which, with almost unerring certainty will guide it to the object, whilst the erratic ricochet of the rifled projectile can never be depended on.

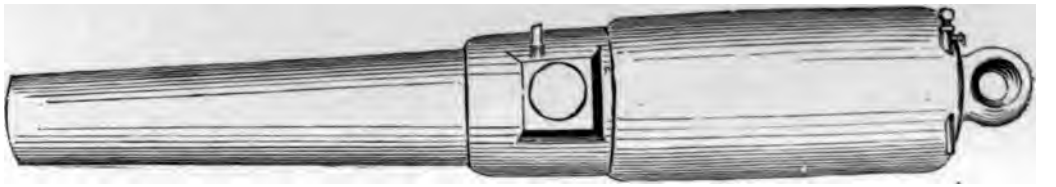
After the description given of the Woolwich guns, which, with the exception of the improvements introducted by Mr. Fraser, are the same in principle as the Armstrong guns, it will not be necessary to give any extended description of the latter. The largest gun shown by Sir William Armstrong and Co. is a nine-inch wrought-iron muzzle-loading rifled gun, weighing twelve and a-half tons (English). The gun is mounted on a carriage and slide, which together weigh four and a-half tons. The compressor for checking recoil (a modification of the American) is wholly of iron. A series of plates, eight or nine inches wide, one inch thick, and placed about an inch apart, are secured to the slide at the ends. Between, and embracing these plates, or bars, are similar ones attached to the carriage, and against this series of plates on one side of the carriage, comes a regulating, or set-screw, which, accordingly as it is screwed up, regulates the recoil by jamming the plates together. The full compression is put on by moving the handle A, in the woodcut, to its present position. Should this operation be neglected, the clutch B, coming in contact with the stud C, when the gun recoils, makes the compressor act of itself. This compressor also serves to control the gun when running in or out in a seaway. The gun and carriage exhibited, have been proved at sea. A similar gun sold to the French Government, has been experimented with at Vincennes during the present season, but such is the secrecy maintained at these French trials, that no one connected with the Elswick Works, where the gun was made, was permitted to be present at the firing. Whether from indifferent gunnery, bad powder, or some other cause, the gun did not do so much execution at Vincennes, as similar guns from the same works have done at Shoeburyness. This may be

due in some measure to a circumstance already noticed, namely, the proximity of the gun to the target. At Shoeburyness the expe



Armstrong 9-inch Gun and Carriage.

rimental range, till lately, was 200 yards, while at Vincennes it is only twenty metres, or twenty-five yards. If, then, the projectiles of these rifled guns are less effective at twenty-five and seventy yards than at 200 yards, it follows, that it will be to the interest of ships armed with smooth-bores to come to close quarters. The round



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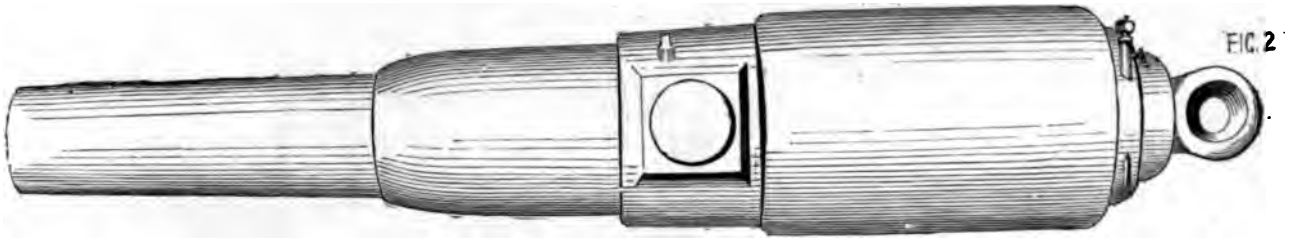

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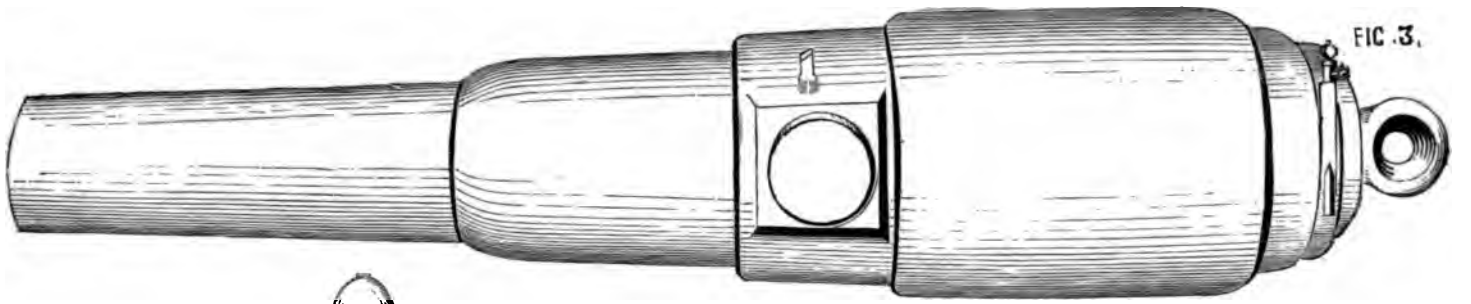

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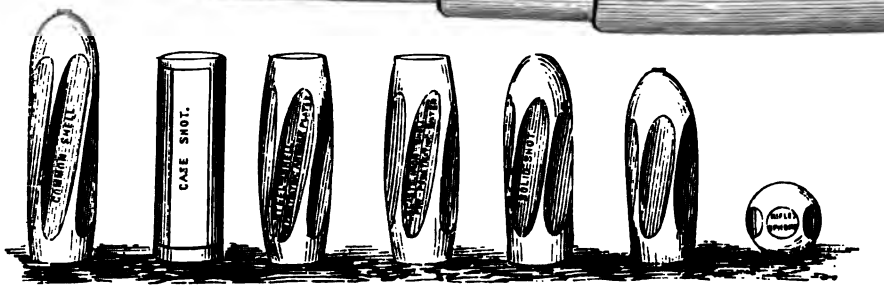


Whitworth Guns and Projectiles.

shot, never having any swaying or wobbling motion, has its maximum penetrating power at the muzzle of the gun. One of the steel shot fired from this Armstrong gun at Vincennes, at twenty-five yards range, direct at the target, actually struck it with its side, and stuck in the soft iron plate, almost parallel with the front of the target. This, and other rounds fired the same day, seem to prove that these shot, at short ranges, have not acquired the direct flight which they obtain after travelling 200 or 300 yards.

Near the display of the Elswick gun-factory, are the guns of Armstrong's great rival, Mr. Whitworth.

The heavy guns exhibited by the Whitworth Company, are a 32-pounder (Fig. 1) a 70-pounder (Fig 2), and a 150-pounder (Fig. 3) which, with the several specimens of shot and shell, are illustrated opposite.

"The leading features of Mr. Whitworth's system," says *Engineering*, "are the hexagonal bore, the sharp twist of the rifling, and the great proportional length of the projectiles; and these three features being all dependent on each other. Without rifling of sharp twist, it would be impossible to give the long projectiles that rapid spin which is essentially necessary to keep them steady, and this sharp twist in its turn necessitates the adoption of such a form of rifling as can impart the required spin without incurring the risk of stripping the projections on the projectiles. We have called the bore of Mr. Whitworth's guns hexagonal; but this is scarcely a correct term. The sectional form of his projectiles is a hexagon with the corners cut off, the lines cutting off the corners being arcs of circles struck from the centre of the hexagon. If the bore of the gun was made of precisely the same shape as the shot, the effect would be that the shot, being slightly smaller than the bore, would, when being driven out, bear upon the bore at each corner only. To avoid this, and give the shot greater bearing surface, Mr. Whitworth gives the bore of his guns a kind of twenty-four-sided form, each bore being formed by twelve straight lines and twelve arcs of circles, disposed as follows:—To a casual observer the bore of the Whitworth gun appears to be a hexagon, with the corners cut off by arcs of circles, as in the case of the shot; but really each side of the hexagon is divided into two parts by a kind of shallow groove cut down its centre, this groove being an arc of a circle struck from the centre of the bore. The two parts of the side of the apparent hexagon, which are on each side of the groove, are not in a straight line with each other; but each inclines slightly outwards from the centre of the bore, that edge of each side which

is next the shallow groove being the nearest to that centre. The effect of this arrangement is, that when the projectile twists in the bore of the gun to the extent allowed by the windage, the six flat sides of the shot are brought into free contact for nearly half their width with six "half-sides," as we may term them, of the bore, and the amount of bearing surface of the shot on

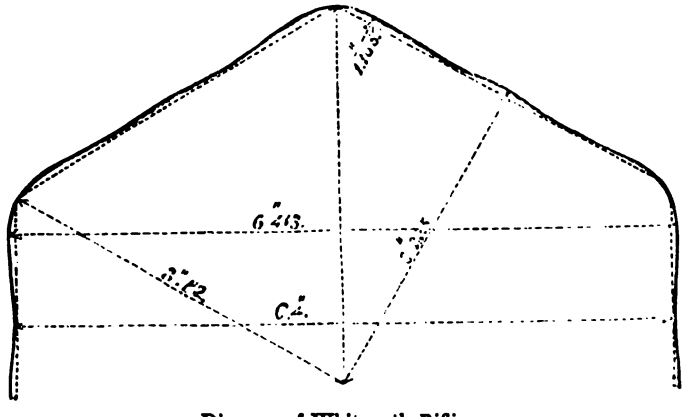


Diagram of Whitworth Rifling.

the bore thus given is very considerable. [The accompanying diagram will illustrate this explanation.] Whilst speaking of this twisting of the shot in the bore of the gun, we should mention the effect it has of equally distributing the windage all round the projectile. In an ordinary rifled gun a shot lays on the bottom of the bore whilst being fired, and the greatest windage therefore takes place on the upper side; but in Mr. Whitworth's guns the case is different, the projectile directly it starts becoming accurately centred, and the windage being thus made equal on all sides. This is an important matter, as it not only equalises the wear of the bore from the blowing through of the powder gases and the grains of unconsumed powder carried by them, but also tends to improve the accuracy of the flight of the projectile."

In range and accuracy the Whitworth guns have few, if any equals. At the Armstrong and Whitworth trials, the mean range of eighteen rounds of the seventy-pounder, at twenty-one degrees elevation, was 7,965 yards, whilst that of the muzzle-loading Armstrong of the same calibre, was 6,330 yards, and the range of the breech-loader was only 5,821 yards. Thus the Whitworth was thirty-seven per cent. superior to the breech-loading Armstrong, and twenty-six superior to the muzzle-loader. In regard to accuracy, the Committee say, that "at ranges greater than 3,500 yards, the Whitworth gun exhibits a decided superiority over the muzzle-loading Armstrong, and this latter a very marked

superiority over the breech-loading Armstrong." "It further appears," they say, "from the table of ranges, combined with an inspection of the probable rectangles, that the Whitworth gun made good practice up to a range of 8,000 yards; which is about 2,000 yards in excess of the ranges attained by either of the Armstrong guns, at the same elevation of twenty-one degrees." Throughout the whole of these trials, the superiority of both the Whitworth gun, and the Armstrong muzzle-loader, over the breech-loader, was very marked. Indeed these experiments seem to have finally settled the breech-loading question in England, at least, so far as regards Field and Heavy Ordnance.

Lying beside the Armstrong and Whitworth guns is a cannon of about thirteen tons in weight, and nine-inch bore, manufactured at the Elswick Ordnance Works, and exhibited by Major Palliser.*

* "This gun is constructed on the plan advocated by Major Palliser, a plan which, in a lecture recently delivered by him at the United Service Institution, he confidently predicted will shortly become universal. The gun consists of an inner barrel of coiled wrought iron, round which, when placed in a mould, a casing of cast iron was run in the molten state. It has stood some very heavy charges, having fired eighteen or twenty rounds with forty-three pounds of powder, eighty-seven with forty-five pounds, and four with fifty-five pounds of powder, and with 250 lbs. shot. The inner tube is full of faults, the coils having become separated by the action of the gas, and it seems probable that a few more rounds would have destroyed the gun. This inner tube was made with especial care, under the immediate superintendence of Mr. George Rendel of the Elswick firm, and Major Palliser acknowledges the care and skill with which he carried out the operation. At the same time, however, it is stated that this inner barrel was very defective, and that some of the coils were imperfectly welded, whence their separation was comparativelyeasy. If this be so, it is a strong argument against the possibility of making wrought iron tubes of larger size with certainty, and tells in favour of those who advocate steel inner barrels. Major Palliser, however, insists that it matters but little of what the outside of the gun be composed, so long as the interior, or heart, is of coiled wrought iron. Whether the system be adopted or not for new guns, there seems little doubt that the principle will be extensively applied to the conversion of the smaller cast-iron guns of the service into rifled ordnance. The principle of that conversion depends upon the same supposition as the construction of the new guns, that the life of the piece is in the inner tube. There can be little, or, indeed, no doubt as to the feasibility of making perfectly sound wrought-iron coiled tubes up to six inches in calibre; but when we come to enormous charges the smallest defect of welding will be sufficient to give the subtle gas power to separate the coils; and that very defect is more likely to be present in the larger than in the smaller tubes."—*Standard.*

It consists of a coiled wrought-iron tube of about two inches in thickness, over which is cast, an ordinary cast-iron cannon. Several guns manufactured in this crude and unscientific fashion have been tested at Woolwich, and failed to meet the requirements of the Government. A system of strengthening old cast-iron cannon, by lining them with soft iron tubes, has also been extensively experimented on at Woolwich by Major Palliser, but none of these guns are shown in the Exhibition. This system was first submitted to the authorities in England by Mr. Parsons, an American, who proposed to use a steel tube; but while the similar and subsequent proposals of Major Palliser receive every attention, those of Mr. Parsons are ignored, and consequently, the experiments in connection with the lining of cast-iron guns are chiefly directed by the former. Few of these guns, however, have as yet been properly tested. The test to which they are subjected consists of a few rounds with increasing charges, which, in no wise equals in severity that to which the French subject all the metal brought to their Arsenal at Ruelle. Whether steel or wrought iron be the best lining for cast-iron guns, is at present a much debated question in Europe, especially in England. Foremost amongst those who side with the iron tube is Sir William Armstrong, but when he had to match his own gun against the steel-lined guns of Mr. Whitworth, he abandoned his favorite metal for that of his rival. The British authorities are now making all the Woolwich guns with steel tubes bored out of the solid bar, which argues that they consider the steel tube to be the best. This fact may perhaps influence the conversion of the cast-iron smooth-bores into rifled guns, though nothing but a fair and thorough trial will set the matter at rest. The following extract from a letter of Mr. Parsons, to the London *Standard*, shows that he does not fear the result of such a trial.

"Let two sixty-eight pounders," says Mr. Parsons, "be converted, the one on Major Palliser's plan, the other on mine, each of us having his gun altered according to his own design and under his own superintendence, and with all the latest improvements, the distinction between the two to be, that Major Palliser's is to have a wrought-iron coiled tube introduced through the muzzle, while mine is to have a reinforced steel tube introduced through the breech end, both guns to be of the same calibre of eight inches and to be rifled exactly alike, and to be tested to destruction by continuous

firing with charges of 30lbs. of powder and 150lbs. of shot, and the one whose gun fails first, to bear the expense of altering both."

The fact that Major Palliser has not accepted this challenge, seems to imply that, like Armstrong in the hour of trial, he has less faith in his own views than in those of his rival.

The large steel guns manufactured by M. Krupp, of Essen, have not yet taken so decided a position among heavy ordnance, as his lighter guns have among field-pieces. The larger calibres, have not only burst more frequently, but the accidents have sometimes been attended by fatal consequences, and the loss, as a matter of course, has been more marked than in the case of the smaller guns. It is not, however, so much our object to collect lists of past failures, as to take notice of the present state of Ordnance as exhibited in the Exhibition. Here, at least, M. Krupp has demonstrated the practicability of making larger steel guns than any that have yet been made from cast or wrought iron. His great gun, if it has not the calibre of our twenty-inch Rodman, is much heavier, and throws a heavier shot. The gun itself weighs fifty English tons, or 112,000 lbs., and, with its carriage and turntable, it will weigh ninety tons. This gun, of which we give an illustration, is a rifled breech-loader. It is intended for the defence of some important harbor, or naval seaport, and would certainly prove a source of great danger to any iron-clad that might come within its range. The diameter of the bore is fourteen inches, and the weight of the solid steel shot is 1,212lbs. The shell weighs 1080 lbs., and carries a bursting charge of only seventeen pounds of powder. These projectiles are to be fired with charges varying from 110lbs. to 130lbs. The total length of the gun is seventeen feet and a half. It may appear strange that so large a shell should carry so small a bursting charge, but the deep grooves required to hold the lead jacket cut away so much of the shell that there is no room left for a heavier charge. The projectile is made up of the cast-iron shell, 843lbs., lead jacket, 220lbs., bursting charge 17lbs. Total 1,080lbs.

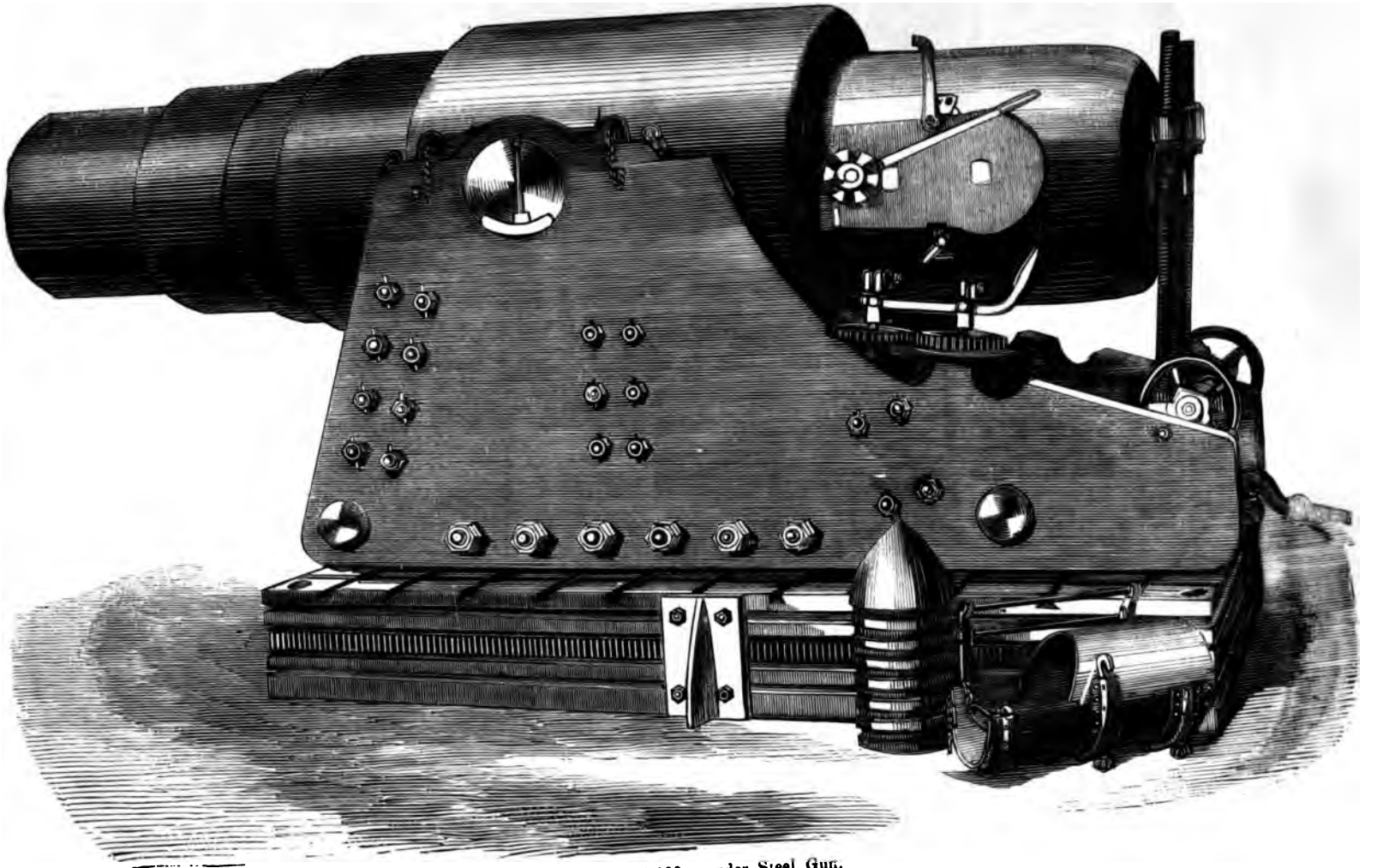
The breech-closing apparatus, is M. Krupp's invention, and is similar in principle to that in use in his field-guns, with the exception that the shot and charge are not introduced through the

extreme end, but through the side of the breech. The inner tube of this gun is its most important feature, and when finished weighs twenty tons. It was forged, under the fifty-ton hammer, from a massive ingot of forty and a quarter tons, thus the waste in turning, boring, etc., has been over fifty per cent. The cast-steel rings are threefold at the powder chamber, and twofold nearer the muzzle; these rings weigh altogether thirty tons, and have been manufactured in a manner similar to the tires for railroad wheels, from heavy masses and without welding.*

The gun has not yet been proved or even fired, so its success is still problematical. Its weakest point is clearly its breech-closing arrangement, or rather the great slot cut through the central tube to receive the shot and charge, and the closing breech-piece. True, the strain at this point will be wholly a tensile strain, but the vibratory action to which the central tube will be subjected, immediately behind the enormous re-inforce rings, may prove the ruin of the gun.

This cannon was in progress of manufacture for sixteen months, day and night, without interruption. A special railroad waggon had to be constructed to bring it to the Exhibition, the railway companies having none strong enough to carry it. This waggon constructed by M. Krupp has twelve wheels, and is manufactured entirely of steel and iron. The exhibitor of this monster cannon says, "the necessary mechanism for working the gun is such, that two men can quickly and easily elevate, depress, and turn the gun, and can with the greatest speed and certainty follow and cover any passing armor-plated vessel." Nothing is said of the facilities for loading, which is fully as essential as the training and elevating of the gun. The cost of the gun with carriage and turn-table is over £100,000. M. Krupp has presented it to the King of Prussia. The largest gun, made from one piece of steel, exhibited

* Large ingots of cast-steel are forged out into flat lengths, from which are cut rectangular pieces corresponding with the weight of the proposed tire. These pieces are forged into bars which are split down the centre to within a certain distance of each end; wedges are then driven into the slot, and the bars gradually opened out and worked under the hammer into a ring, which is ultimately finished in the rolling mill.



Krupp's 1,000-pounder Steel Gun.

by M. Krupp, is a nine-inch breech-loader, weighing twelve and a quarter tons. This gun, with the exception of the trunnion ring, forged as described without welding, was made from one ingot, and forged under a fifty-ton hammer. It has been fired 120 times, with full charges—forty-five pounds of powder. The total length of the gun is 180 inches, the usual charge is from forty to forty-five pounds, the weight of the solid shot being 330lbs., and that of the shell 275lbs. The polygrooved rifling and lead-coated shot of M. Krupp, can only be used with advantage in breech-loading guns, hence, whilst other makers are abandoning breech-loading, for muzzle-loading cannon, M. Krupp is taking quite the opposite course, and seems to have come to the conclusion that all large guns ought to be breech-loaders. In this, as already observed, he is seconded by the artillerists of Ruelle. The heavy coating of soft lead, which surrounds these steel shot, will demand great care in storing and transportation, while the deep grooves cut in the steel to retain the lead, reduces the strength of the shell to such an extent, that it can only contain a very insignificant bursting charge; the Armstrong and Whitworth nine-inch shells carry a bursting charge of from ten to fourteen pounds, while that of M. Krupp is under four pounds.

That the manufacture of these homogeneous cast-steel guns is improving, there seems to be little doubt, and in this special branch the business done at Essen clearly shows that M. Krupp occupies the first place in Europe. An establishment that can produce 60,000 tons of finished steel annually, may reasonably be expected to bring its productions to the highest attainable degree of excellence in less time than smaller concerns, and if these weakening breech-arrangements could be dispensed with, cast-steel guns would doubtless soon supersede the complicated coiled wrought-iron systems. The want of confidence in steel guns is not attributable to any inherent defect in the metal, so much as to the absurd fancies introduced by their designers, and which on trial have frequently resulted in disastrous failures. That steel, under the most trying circumstances, is daily proving its reliability, is evinced in the case of the rails, tyres, and crank-shafts used for railroad purposes. The odium which seems to stick to steel guns

did not originate in the excessive number of guns burst, but in the nature of their destruction. The life of a Woolwich gun (perhaps the best of the wrought-iron type) is about 400 rounds. By a Parliamentary Report, up to April, 1866, twenty, out of thirty-three 7-inch Woolwich guns, upwards of sixty per cent., were either burst or rendered totally unserviceable by an average of 210 rounds. No such record of failure can be produced against the guns of M. Krupp. The chief indictment brought against them is, that they burst explosively, while the wrought-iron gun dies gradually like one in a decline. It succumbs without noise, frightening nobody, whilst the other (like a sudden and untimely death) demoralizes all who behold and survive its destruction. A mild tough metal, that will more effectually resist such explosive action, is the grand desideratum with the makers of steel guns. That such a metal is attainable there can be little doubt, nor is there any quarter from which there is no more reason to expect its appearance, than the establishment of the great gunmaker of Essen.

Krupp, however, is not the only maker of steel guns in the Exhibition. He is not even the only German maker. Berger and Co., of Witten in Westphalia, mentioned in connection with "Field Ordnance," have also some guns of large calibre. The largest is an eight-inch breech-loader, somewhat similar to Krupp's, and which appears to be more simple [see woodcut]. The wedge or closing breech-block A, has a flange *b*, the rim of which is partly cut away to allow it to pass a notched keeper-block C, and when the wedge is pushed home, a half turn of the handle brings the uncut part of the flange into the notch of the block C, and at the same time, and with the same movement, a screw acts upon a tightening wedge, or key, which effectually jams the breech-piece, and closes the breech. Many of the guns for the Prussian and Russian Governments have been made in the factory of Messrs. Berger and Co. But the reputation of this firm is chiefly due to the production of steel gun-barrels for the Prussian Army, the needle-gun being, almost without exception, provided with barrels of Berger's make, drilled out of the solid bar. *Engineering* considers that Berger's steel, is

fully equal to Krupp's in quality, and that his small gun barrels, especially, are more uniform in quality than those of any other maker.

Berger's 8-inch breech-loader.

A hooped, soft-steel gun, of sixteen tons in weight, is exhibited by the French firm of Petin and Gaudet. This gun is about eighteen feet long, of nine and a half-inch bore, and is intended to carry a shot of 300 pounds weight. Messrs. Petin and Gaudet, as before stated, are the principal makers of steel hoops, and trunnion rings, in France, and if they are as successful with their heavy steel ordnance, as they have been with their re-inforce rings for large cannon, their soft steel guns may do much to bring to greater perfection this branch of the Munitions of War.

The guns in the Exhibition which come nearest to our own in shape, and perhaps in the quality of the metal, are two cast-iron 'Finspong" guns, exhibited by the Government of Sweden. One is a smooth-bore, of eleven inches, without any re-inforce, and the other a four-grooved rifle of nine inches, with a steel re-inforce at the breech. The test to which these guns is subjected, is of the severest kind, as the following applied to a nine-inch smooth bore testifies. Two rounds are first fired with thirty pound charges and a shot weighing 160 pounds; then the charge is increased to forty pounds, at which it continues throughout the trial. But, after one round with the same weight of shot, five rounds are fired with two shot, or 320 pounds weight. Then five rounds with three shot,—equal to 480 pounds weight, and five with four, equal to 640 pounds weight of metal. A shot is then added

every round till they fill the bore—numbering eighteen shot—2,880 pounds; all of which the gun stands without giving way. Compared with such a trial, the proving of the wrought-iron, tube-lined guns at Woolwich is mild in the extreme.

Sweden was one of the first countries that produced cast-iron cannon. As early as 1568 the Swedish Navy was armed with cast-iron guns. The ores of Sweden have long been famous, and the Swedish guns soon acquired a renown for their excellent and enduring qualities, and during the seventeenth and eighteenth centuries, the greater part of the States of Europe purchased their cannon in Sweden. The ores of certain districts, especially, possessed the necessary qualities for furnishing a superior and solid casting. But the exportation of so many guns during the above-mentioned period, led to the erection of a great many cannon foundries, and, as already observed, many of these made use of inferior ores. The consequence was that many of the guns burst, and the reputation so long enjoyed by Sweden, and to which she was justly entitled, began to decline. The necessity for a rigid inspection of ores was thus forced upon the Swedes, when it was found that certain mines only furnished ores that were suitable for the fabrication of cannon. This caused the decline of many foundries, and Sweden very soon began to regain the reputation she had lost through inattention to the materials used in the manufacture of her guns. Now, her cannon founders are not satisfied merely with the most searching selection of their materials, but by great perseverance and study in the perfection of their works, they are endeavouring, with a great degree of success, to produce cannon which for strength and durability will surpass the cast-iron guns of other countries.

In bringing our Report on "Heavy Ordnance" to a close, it is but right to say, that all the heavy guns exhibited have not been mentioned. There are cannons from Russia, Belgium, and other countries, which have been passed by because they contain nothing special in regard to the mode of their manufacture, or their working arrangements.

Considered in regard to the materials used in their construction, the guns we have commented on may be divided into three classes,

namely, cast-iron, cast-steel, and wrought-iron guns. The cast-iron weapons are represented chiefly by the French and Swedish guns, the former being breech-loaders, and the latter muzzle-loaders. We have recorded the particulars of the test to which the Swedes subject their cannon, and though those of the French may be equal, as regards the quality of the metal used, we do not believe that their breech-closing arrangement would stand such a test. The cast-steel guns exhibited are chiefly breech-loaders also, all greatly weakened and more or less complicated, and enhanced in cost, by an arrangement of doubtful advantage. The wrought-iron system, of which the British Government and Sir W. Armstrong are the chief exponents, has not, especially in the larger calibres, been saddled with the breech-loading difficulty, and if these guns could only live a reasonable number of rounds, their immunity from explosive bursting would give them a great advantage in war. Men will always take more kindly to a gun that gives them warning of approaching destruction before exploding in their hands, but 400 or 500 rounds is too short an existence for such costly weapons. The Whitworth gun, with its homogeneous tube, and weldless hooping, though not wholly secure against explosive bursting, is perhaps, for calibres up to seven inches, the strongest and most enduring gun we have examined. It is second to none in accuracy of firing, whilst in range, it far surpasses everything in the Exhibition, except the "Ferris gun" in the American Section.

CHAPTER V.

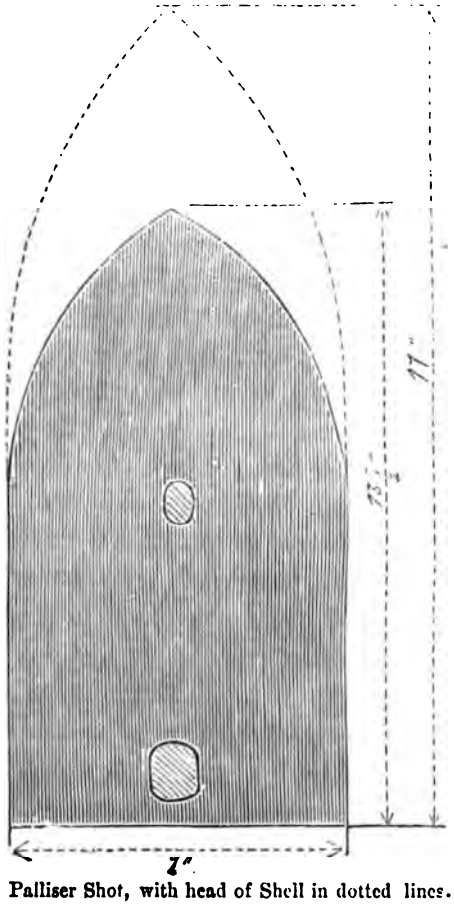
PROJECTILES.

HAVING frequently referred to shot and shell, in speaking of the guns, there remains little to be said under the head of "Projectiles," save to notice anything specially new and interesting. We are daily hearing of some terrible missile that is to make an end of war by destroying everything within its range, but which, when closely examined, or subjected to a trial, is often found to be inferior to well-known projectiles in general use. As an illustration of these a single case will suffice. A Monsieur Landi, of Paris, exhibits a cartridge that fires many shots ("*La cartouche a plusieurs coups*") at one loading. He proposes to fill the barrel of the gun with cartridges put together like a candle, or a rod, and which, by some very complicated process, are to be fired off in succession. The first is to be fired from the muzzle, and it communicates the fire, by means of a slow match, to the next below it, and so on till the whole are fired. Round bullets and smooth bore guns, are necessary for this extraordinary cartridge. M. Landi evidently never heard of rifled breech-loaders, and doubtless took his idea from the common Roman candle used in pyrotechnical displays, for he contends that his gun, once loaded, can be levelled as when advancing to charge, and while the soldier is running, the gun will keep firing without re-loading, or the necessity of pulling a trigger.

Passing by this, and dozens of useful and well-known war missiles, we come to the projectile of projectiles, judging from the large sum of money which the British Government paid to the inventor—the Palliser chilled shot. The British War Department in a "Hand-book of Instructions," says "that in the manufacture

of this shot," (we quote from memory) "care must be taken to select such brands of iron as will *chill through*." Before Major Palliser discovered the process of "*chilling through*," a solid shot of nine or twelve inches in diameter and from 250 to 600lbs. in weight, engineers and iron-founders considered from a quarter to three-eighths in depth a very good chill. But, in truth, the Palliser shot are not *chilled* at all, they are the very antithesis of chilled, they are annealed. The hardness of this shot is due to the nature of the white metal furnished by the Ebbw Vale Company, and not to the iron mould in which the shot is cast. It is well-known that a chill is produced by running the molten metal into a cold iron mould; but this white metal is so hard and brittle in its nature, that if run into a cold mould it would crack, so as scarcely to hold together when taken out. Hence the Palliser mould instead of being cooled to chill the shot, must be heated to prevent the metal from cracking. Even when the shot is taken out of the mould it must be buried in hot sand to prevent its cracking by being too suddenly cooled. "Chilled shot," to the inventor of which the British Government paid $75,000, is therefore a misnomer. Shot made from Pontypool iron or white metal, cast in sand in the ordinary manner, are equal in penetrating qualities to those which Major Palliser casts in iron moulds, and have the advantage of being produced at much less cost, as six of the former, so far as labour is concerned, can be produced as easily as one of the latter. The shot cast in sand from this metal, sometimes show as if unsound, having a cracked appearance on the outside, which may be accounted for by the fact that the cool sand is really a better "chill" than the hot iron mould used at Woolwich. The Palliser shot exhibited by the War Department, and by Sir William Armstrong, have all been cast in iron moulds; they are split open to show the texture and color of the metal, but it is impossible to trace even the faintest outline of a chill, in any one of them, save in the core of one of the shells, where the metal has the appearance of being chilled about ' of an inch deep. Mr. Whitworth shows a shot made for his guns of the same metal, also broken in two. It was cast in sand, and is evidently a better casting, both as regards the skin of the shot and the closeness of the metal, than any other shot of this nature exhibited.

Leaving the metal of the Palliser shot, we come to consider how far its form is conducive to its efficiency, first, as to penetration, and second, as to accuracy. The penetrative power of the Palliser



Palliser Shot, with head of Shell in dotted lines.

shot, when fired at a right angle to the plate, is perhaps greater than that of any other projectile, other conditions being alike. This is due in conjunction with the hardness of the metal, to the ogival form of the head, which is illustrated in our woodcut. Without entering upon the theory why this form of shot in direct firing has such penetrative power, we may observe that this power diminishes more rapidly than that of the flat-headed shot, when the firing is more than thirty degrees from a rectangular line.

The Palliser shot of 115lbs. weight, fired from the Woolwich 7-inch gun with fifteen pounds of powder, passes easily through an unbacked plate of soft iron seven inches thick at seventy yards

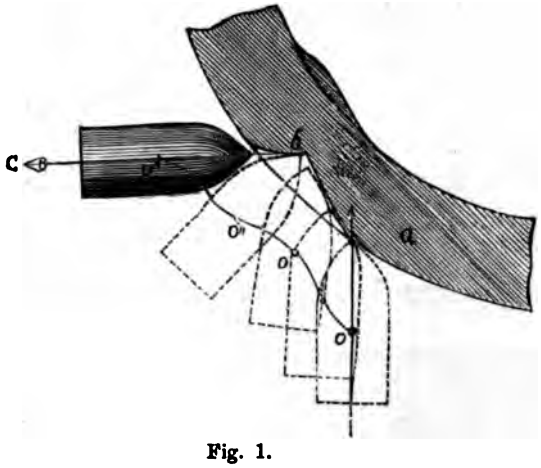


Fig. 1.

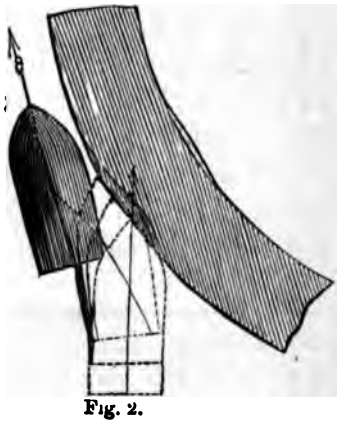
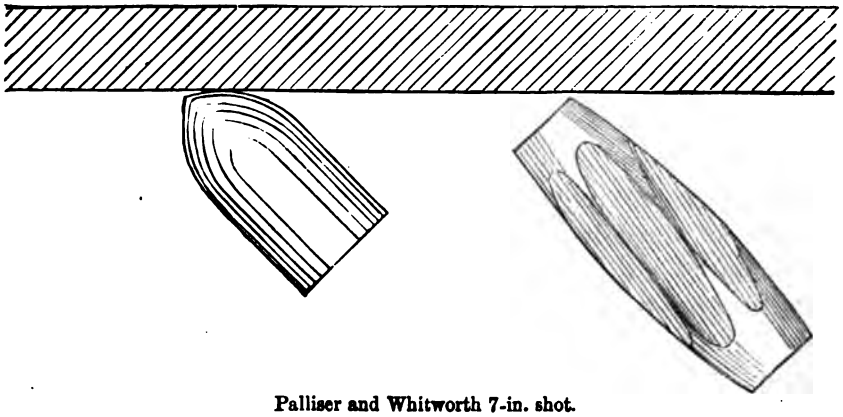


Fig. 2.

range. But at an angle of thirty degrees the same shot with twenty-two pounds charge invariably fails to penetrate, whilst at an angle of forty-five degrees its effect would be almost nil. Figs. 1 and 2 are sufficiently near what the experiments have established, to give a fair idea of the effects which these shot are likely to produce on cupolas and turrets, save when, as it were by accident, they happen to strike at a right angle. In Fig. 1 the point striking at an angle of about thirty-five degrees has caught at *a*, when the bearing on the impinging shoulder gradually cants the shot, till at *b*, it loses its hold and flies off in the direction

* Fig. 1 (says the *Engineer*, from which our diagram is copied) "illustrates what may happen when the convex surface is obliquely struck under conditions which enable the point of the shot to catch without holding, and the axis of figure to turn through a certain angle, as while the centre of gravity is passing from *o* to *o'*, or a little beyond, during all which period the ogival point continues to excavate by its forward side only; the other not being exposed to any pressure from the solid; and the oblique direction of the translative velocity of the shot being

of the arrow *c*. In Fig. 2, the shot, striking at a greater angle, merely glances off in an oblique direction from the line of fire. The action illustrated in Fig. 1 shows that the shot has a tendency to right itself, if the angle be not too great, but this righting action is also a jamming action, which fully accounts for the greater falling off in penetration by a departure from a direct line as compared with the flat-ended shot. The Whitworth flat-headed seven-inch shot has frequently penetrated a four and a-half inch plate placed at an angle of forty-five degrees. The following sketch, in which the Palliser and Whitworth seven-inch shots, on a scale of an inch to a foot, are seen impinging on a four and a-half inch plate at an angle of forty-five degrees, will show that the point of the former cannot possibly catch until the friction on the impinging shoulder has made the rear-end of the shot swing about ten degrees to the left. The momentum thus imparted to the rear and



Palliser and Whitworth 7-in. shot.

heaviest end of the shot will carry it round with the same result, as shown in Fig. 1, in spite of the resistance offered by the metal it may scoop out. The latter, on the other hand, bites at once—cuts like a chisel or gouge, destroying the resistance of the plate in detail and going clean through on a line, almost parallel with the

such, that though the interior face of the plate may be bulged, the *umbo* is so much obliquely in advance of the shot that the latter does not penetrate. . . . . The axis of figure rapidly is wheeled round into the position at *o*", and thence to *o*"', when the shot flies off with its base at first foremost in the direction of *o*"" *s*."

flight of the shot. It thus appears that the cupolas of Monitors and sloping sides of ships like the "Dunderberg," have little to fear from Palliser shot, and even the roll of an ironclad in a moderate seaway will impart such an angle to her sides, as will give a large percentage of protection against these projectiles.

Some writers, both English and American, contend that at long ranges the line of trajectory will be such that the shot will strike almost at right angles to the plate, on the sloping side of a ship thus neutralizing the advantages claimed for this method of construction. But at this point the shot has lost too much of its velocity to effect penetration. Penetration demands a high *velocity*, not a high *trajectory*, and a high velocity for a shot aimed at a low mark, implies point-blank firing or very little elevation.

The Palliser shell, if shell it may be called, has, as we have shown, a head more pointed than the shot, but owing to the brittleness of the metal used, the sides must be very thick, and therefore it carries an insignificant bursting charge. For the 7-inch gun it is under two pounds, and for the 9-inch under four pounds. The metal of the shell breaks up in passing through a plate of moderate thickness, so that by the time it reaches the backing it has ceased to be a shell. The powder therefore of the bursting charge being unconfined rarely does much damage.

To the second point, "Accuracy," we have already adverted when speaking of the Woolwich guns. We did not intend to bring a charge of indifferent firing against the guns themselves, but gave some facts to show that when firing Palliser shot the accuracy was very indifferent. A report of some experiments with Palliser guns and shot made in September* appeared in the *Standard*, at the time, and was evidently written by a friendly hand:—

"And now," (says the writer) "came the most interesting event of the day, the trial of two of Major Palliser's converted guns. The first was a sixty-four pounder rifled muzzle-loading gun converted by the insertion of a wrought-iron tube from a thirty-two pounder cast-iron gun of 58 cwt. The range was 500 yards, and the target was the "Warrior," No. 22.

*Since this date the accuracy of these guns has been improved by lengthening the shot about one-seventh.

The charge used was sixteen pounds of powder, with a Palliser eighty-four pound shell filled with a bursting charge of seventeen ounces. The first shot was in good line, but the elevation was rather too great. The shell just missed the top of the target, and, striking a bolt in some heavy woodwork behind, buried itself in fragments in the timber. The second shell struck the target on a sound spot three feet eleven inches from the lower right-hand corner, passed through the 4½-inch plate, and was there broken on one of the ribs of the inner skin, which, however, was not broken, though a part of the timber backing was driven into matchwood. The estimated force of impact of this shot was forty-five tons per inch of circumference. The third shot ever fired from this gun at this range *caught* the target at the upper right-hand corner, fourteen and a half inches from the right side, and twenty-nine inches from the top."

The writer evidently breathed more freely when the shot *caught* the target.

"The fourth shot, which was fired at No. 28 target had a little too much elevation, and only punched a bit about half its own diameter out of the upper edge of the target, which there is no doubt it would have penetrated had it struck fair. It was now nearly half-past five o'clock, and it became necessary to cease practice for the day. This morning the programme will be resumed and completed. Among the experiments to-day will be one to ascertain the respective range and accuracy of Palliser shot with long and short heads, and with a reduction of windage. Forty rounds will be fired altogether, with charges of twenty-two pounds, at three degrees and five degrees, elevation."

These experiments, for some reason or other, have not been reported in the *Standard*.

The above guns were rifled on the Woolwich system, the twist of which may not suffice for very long ranges, but at moderate distances the firing (before the Palliser shot in its present form was adopted as the national projectile) was very respectable. Referring to a "Report on the trial of rifled guns, June 1865," submitted to Parliament, we find the Ordnance Select Committee saying:—

"The particular object of the experiment, was to ascertain if possible whether the smaller stud, which in the French system is situated behind, but in Major Palliser's plan, as tried in the Woolwich gun, is placed in front, contributes to accuracy by assisting to rotate the shot, or only by preventing its oscillation in the bore. To test this, the smaller stud which was in front, and, as intended by Major Palliser, ought to give rotation near the muzzle, was very much reduced in size, in the expectation that it would not touch the driving edge. An examination of the shot after their recovery shows that this expectation was not realized, the smaller studs are all worn

and evidently took the rifling. So far therefore the object of the experiment was not answered, but the practice is of some importance in support of the Committee's recent recommendation of this mode of rifling."

The following minute is then given, 20 shells filled with sand and plugged—100lbs.; charge twenty pounds; elevation 5° 7′.

Mean Recoil.	Mean time of Flight.	Ranges.			Mean Difference of Range.	Mean Observed Deflection.	Mean Reduced Deflection
		Minimum.	Maximum.	Mean.			
Feet.	Seconds.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.
3·0	7·36	2,648	2,727	2,700	13·8	11·3	2·1

The Committee add, that "the uniformity of this practice is remarkable, and it has been but seldom exceeded," and after giving a table of twenty experiments with other guns, including the breech-loading Armstrong, the shunt, and Scott guns, they say, "the Committee do not desire to lay too a great stress upon a single example of very good shooting, but as the merits of the Woolwich system of rifling are still under consideration they beg to add the foregoing practice to the record."

From these, and other evidence that could be adduced, it is clear that the recent indifferent firing of the Woolwich guns with Palliser projectiles is due more to the shot than to the gun. To obtain the ogival form of head best suited for penetration with the white metal of the Palliser shot, the bearing of the shot has been greatly shortened, which, with the insufficient spin consequent upon a slow twist, originates and keeps up for a time the wobbling motion already commented on. This defect might be obviated by lengthening the shot, but that would increase its weight and diminish its velocity which, latter is especially essential to its penetrative capacity. At the moderate striking velocity of 900 or 1,000 feet, per second, which after all is that most likely to prevail in actual conflict, it is presumable that the hard-metal shot with the ogival head would expend, proportionately, a greater amount of the work it contained on its own destruction, than at the higher velocities attained at the Shoeburyness experiments.

In alluding to heavy rifled Ordnance generally, we have spoken

of the British Government in having adopted these weapons exclusively for their naval armaments, as "putting all their eggs into one basket." The Ordnance Select Committee seem to think that so far as their shot is concerned they will be costly and troublesome "eggs" to transport. "The supply of rifled projectiles," they say, "will always be limited from their bulk and weight and cost. It is not to be expected that they will be expended so freely as round shot, which will also be good enough for instructional and other purposes, and can be carried in any desirable quantities." The committee here refer to the firing of round shot from rifled guns, but such shot, from the small calibre of the guns, will be very harmless missiles against armor-plates.

The ordinary service Shrapnel shell which was tested against

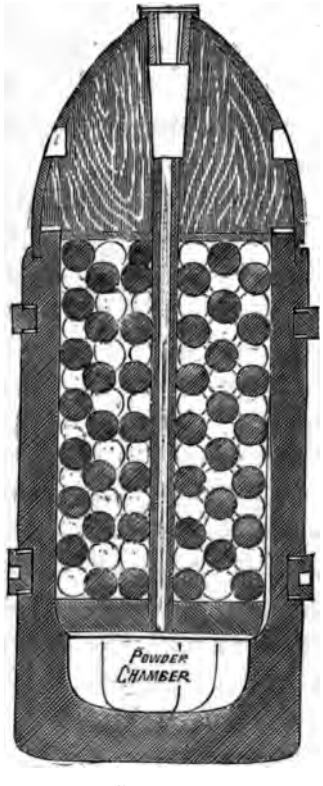


Fig. 1.

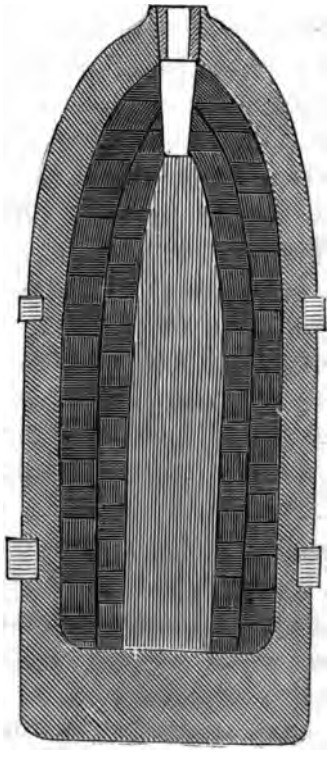


Fig. 2.

the Segment shell (invented by Sir William Armstrong,) at the

Armstrong and Whitworth trials, is shown in the collection of the Laboratory Department of the Woolwich Arsenal. Fig. 1 represents this shell in section. The ignition is regulated by a time fuse which fires the charge at the base of the shell. The explosion breaks away the thin head, sending the bullets forward with a force as if fired from another cannon. Fig. 2 is the Armstrong Segment shell, the square pieces or segments of which are scattered by the bursting charge. The following table of experiments with these shells at the Armstrong and Whitworth trials, shows some curious results. The shells were made to strike a screen so as to explode at the required distance in front of the targets; the shells to strike the screen at various heights from the ground up to ten feet. Concussion fuses were used at this trial.

"Practice with Whitworth Shrapnel, and Armstrong Segment shells."

"Area of target face 27 ft. × 9 ft., except at the 800 yards range, when, for the latter rounds at 50 yards burst, there was an increase of three targets, making 54 ft. × 9 ft. face; at the 100 yards burst, the area of face was increased to 72 ft. × 9 ft., 2 in. thick.

Number of Rounds.	Distance of Targets in front of burst.	Whitworth M. L.			Armstrong M. L.		
		Through.	Lodged	Struck.	Through.	Lodged.	Struck.
	Yards.						
10	25	350	45	8	388	93	57
10	50	224	18	18	151	41	16
10	100	113	24	61	43	68	62
	Range, 800 Yards.						
10	10	603	36	17	546	58	39
10	25	540	41	12	328	174	65
10	50	348	21	15	167	157	72
10	100	228	33	7	26	100	48"

There is reason to believe that the ranges of these tables ought

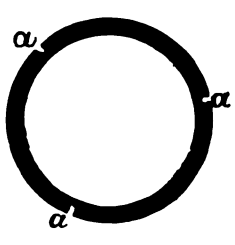
to be reversed, otherwise both have done greater damage at 800 yards than at 600 yards. The Shrapnel and Segment are nearly alike as regards the number of hits in the 70 rounds, the numbers being respectively 2,772, and 2,699, but the through hits of the Shrapnel are 2,406 to 1,649 of the Segment.

To merely mention the various projectiles exhibited in the Exhibition, would occupy a considerable space. The case of the Laboratory Department of the Woolwich Arsenal alone, contains about a thousand different pieces, sections &c., chiefly relating to projectiles, cartridges, and fuses. It contains round and cylindrical shot of various sizes and kinds, in short, a sample of nearly every shot and shell used in the British service. There are shell and sections of shell, segment and shrapnel charged and empty, spherical and diaphragm, mortar and liquid shell, besides rockets, smoke-balls, and signal lights. A specimen of almost every article produced in the Laboratory Department is exhibited in this case. Among these, a parachute light-ball (10-inch) is especially interesting. It is a hollow sphere of thin iron (about a quarter of an inch thick), enclosing a thinner shell made in two halves, and lightly fastened together. In the lower or permanent half of the inner

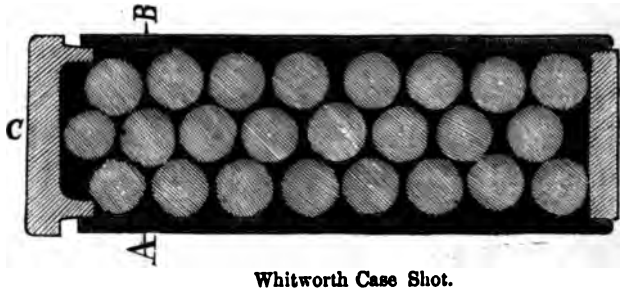
Parachute Light-Ball.

shell is a peculiar illuminating compound, and in the upper half, a parachute of thin cotton is snugly stowed. The ball is fired from a mortar, with a light charge, so as to reach a point over the enemy's works, when a time fuse ignites a small bursting charge which throws away the outer shell, and the upper half of the inner, thus freeing the parachute. The parachute, to which the lower half of the shell is attached by lines and small chains (the latter next the shell so as not to be burned), expands and slowly descends, while the illuminating compound which has been ignited by the bursting charge, lights up the surrounding country. This compound burns for a space of about three minutes, and so illuminates the enemy's works that any operations undertaken under cover of night are detected. Our woodcut represents the parachute light-ball immediately after the explosion of the bursting charge, and the expansion of the parachute.

In the adjoining building, Mr. Whitworth shows various specimens of his common case-shot, the effects of which have already been referred to and illustrated by a diagram. This projectile, or rather collection of projectiles, consists of a thin metallic shell,



Cross Section on A B.



Whitworth Case Shot.

filled with bullets as shown in the woodcut. The spaces between the bullets are filled with rosin to keep them in position. The case is weakened, as shown at *a*, *a*, *a*, cross-section, to facilitate its breaking on leaving the gun; and in order to render this certain, the cap, *C*, which is not pushed or driven home before loading, has as much taper as suffices to open or split the shell, when the freed bullets, which keep pretty well together, produce an effect, at from 200 to 500 yards, similar to that of a well-concentrated charge of small shot from a fowling-piece.

If a projectile of this description—each internal sphere being a percussion shell instead of a solid shot—could be used in our fifteen or twenty-inch guns, the effect on anything but an iron-clad would be terrible, especially at short ranges. Even against iron-clads they would make fearful havoc on the deck, besides having a good chance of entering at the portholes, especially such hopper-shaped portholes as those of the British iron-clads "Hercules" and "Penelope." Such projectiles could only be fired with advantage from smooth-bore guns of large calibre; they are not rifle projectiles, if any spin were given to the case before it breaks up, it would have the effect of scattering the shot, and a case fired from the small bore of a rifled cannon of the ordinary size, would not contain shells of sufficient capacity. A case two feet long, suited to the bore of our fifteen-inch guns, would contain twelve spherical shells of six and a half inches diameter, each of which, being one and a quarter inch thick, would contain a bursting charge of rather more than two pounds of powder. Such a case shot would weigh about 650 pounds.

Before closing these hasty remarks on projectiles, a kindred subject—Gun-cotton—demands a passing notice. Many who have suffered more from the deleterious, than the explosive, effects of "villainous saltpetre," hoped that the Exhibition of 1867 would throw more light than it is likely to do on the subject of explosives. Messrs. Thomas Prentice and Co., of London, who three years ago established a factory for the purpose of preparing gun-cotton, according to the Austrian process, under the inspection of Baron Lenk, show a varied supply of this explosive chiefly made up for sporting purposes. Baron Lenk, an Austrian General Officer, has been unremitting in his endeavours to bring the preparation of gun-cotton to perfection, and Professor Abel, F.R.S., director of the chemical establishment of the British War Department, considers that Baron Lenk's improvements "contribute importantly to the production of a thoroughly uniform and pure gun-cotton." A full inquiry into a subject that has engaged the attention of scientific men for twenty years would greatly exceed the limits of this report. Therefore we merely give, in the words of the exhibitors, the advantages which they claim for their gun-cotton for military and naval purposes.

"For purposes of artillery"—1. "The same initial velocity of the projectile can be obtained by a charge of gun-cotton one-fourth of the weight of gunpowder. 2. There is no smoke from the explosion of gun-cotton. 3. Gun-cotton does not foul the gun. 4. It does not heat the gun to the injurious degree of gunpowder. 5. It gives the same velocity to the projectile with much smaller recoil of the gun. 6. Gun cotton will produce the same initial velocity of projectile with a shorter length of barrel. 7. In projectiles of the nature of explosive shells, gun-cotton has the advantage of breaking the shell more equally into much more numerous pieces than gunpowder. 8. When gun-cotton is used in shells instead of gunpowder one-third of the weight of the latter produce double the explosive force." "For naval warfare." "Where guns are close together as in the batteries of ships the absence of smoke removes the great evil of the firing of one gun impeding the aim of the next, and thus gun-cotton facilitates rapid firing."

The summing up of the general advantages concludes as follows:—"The patent gun-cotton has the peculiarity of being entirely free from the danger of spontaneous combustion, and it is constant and unalterable in its nature." The above, of course, is from an advertising circular, but if a tithe of the advantages here put forth will stand the test in practice, Baron Lenk and Messrs. Prentice and Co. will have earned the gratitude of every son of Mars.

There is still another class of projectiles in the Exhibition which we might perhaps have passed *sub silentio*, but for the fact that an inventor of this class of missiles has been paid a considerable sum of money as a reward for his invention by a prominent European Government. We allude to explosive rifle bullets. Some experiments have been made in Paris this summer with these projectiles (in this case, a French invention), when one of these bullets burst in the heart of an oak plank, eight inches in thickness, breaking itself into five fragments, and tearing the plank to pieces. Such a bullet lodging in a limb, if it did not shatter it so as to cause the wounded soldier to bleed to death, would certainly inflict such pain as would be tantamount to unnecessary cruelty and torture. For the jagged fragments of the exploded bullet would, on the explosion, take a course through the flesh as erratic as their form is irregular, and thus prevent them from being probed or removed. Many a wounded soldier has lived for years with a bullet in his body or

his limbs, and has after a time suffered but little inconvenience from it, and thousands who have lost limbs altogether, like England's great Admiral, and many in our own country, have done the State and mankind good service after they were maimed. But such would seldom be the case with wounds inflicted by the jagged and ever-tormenting splinters of an explosive bullet. Any torpedo that would sink a ship of war or even a fleet of ships by a single explosion, or any projectile that would sweep away whole battalions at once, would be hailed as a welcome means of shortening the horrors of war; but no such feelings are awakened by contemplating explosive bullets for small arms. Such missiles must ever be classed with poisoned arrows or any other hellish contrivance that will enable men to kill rather than cure the wounded. Explosive bullets, such as those referred to, will never tend to shorten wars. By doing away in a great measure with the necessity for taking care of the wounded, soldiers after a battle will be less frequently brought together to look after their suffering and disabled comrades and bury the dead,—solemn duties, which, by appealing to our better nature, often lead to a cessation of hostilities and sometimes bring about a lasting peace. During the late war when certain ladies applied to General Sherman for permission to go to the front to attend to the wounded, the general in granting their request said:—"It is not necessary for me to say to ladies in your position, that in administering relief to the wounded soldier no distinctions are to be made." "I feel sure," he added "that you will never ask a wounded soldier whether he is friend or foe, before granting him such assistance as it may be in your power to render." Such sentiments as these, which teach us to pray that God would have pity upon all prisoners and captives, not only tend to mitigate the evils of war, but bind people together in union and friendship after a war is ended. They are diametrically opposed to the spirit that originates and employs explosive rifle bullets and poisoned arrows in our day, or that which in ancient times made conquerors drag their captives at their chariot wheels.

CHAPTER VI.

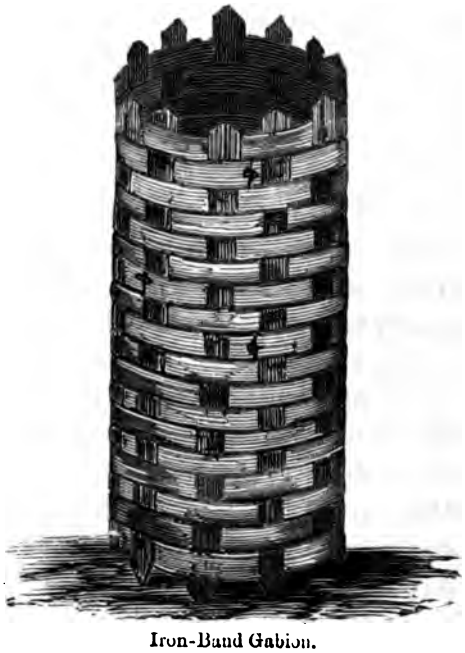
ARMY ACCOUTREMENTS, ETC.

THE exhibit of army accoutrements, and the sundries that go to make up the machinery and necessaries for the transport and maintenance of armies, are, with one or two exceptions, very meagre and commonplace.

In all that pertains to the care, transport, and relief of the wounded the collection of the "International Society for the Relief of Wounded Soldiers," and that of the United States Sanitary Commission, exhibited by Dr. Evans, leave little to be desired. The British War Department not only exhibit all that is new and interesting in war material, but everything calculated to illustrate the everyday life and exercise of the soldier, in every branch of the service. Not only is a soldier's barrack-room exhibited with lavatory and water-closet attached, but a hospital ward with ordinary furniture and conveniences, lavatory, bathroom and closets. There is also a married soldier's quarters, and a room in which are articles used in the soldier's recreation-room, such as draughts, chess and bagatelle boards. Another room is devoted to gymnastic exercises, all the paraphernalia of which, dumb-bells, clubs, single-sticks, foils, etc., are shown. In the park adjoining the building containing the Munitions of War, are exhibited a two-stalled stable, and the heads and points (of the well-known Prussian type) used in cavalry exercise. Within the building are specimens of twelve different kinds of swords and cutlasses, which have been and are now used in the service. Admiral Farragut, on being shown this collection, selected a cutlass which he said was the same as that used in the U. S. Navy, when he entered the service; and the non-commissioned officer in charge said, that "the same cutlass was in use in the British Navy now," having outlived many attempts to supersede it by more showy but less

handy weapons. It is a cutlass with a very slight curve, and a simple bow guard. The British War Office Museum at Paris, is not limited to the display of made-up war material, such as we have described, but it contains samples of nearly every nail and screw in the service. On the sides of two hexagonal trophies, about five feet in diameter and twelve feet high, are arranged a sample of all the tools supplied to the different trades:—"Carpenters, Shoemakers, Farriers, Shoeing-smiths, Bricklayers and Masons, Coopers, Tailors, Wheelers, Collar-makers, Pioneers, Miners, Camp Equipage, and Picketing."

Leaving the general review of this collection, which, although possessing much that is intrinsically excellent, would, perhaps, have been more interesting, if less of what is commonplace had been exhibited, we pass on to notice such of the exhibits, as may possess some novelty or excellence entitling them to special attention.



Iron-Band Gabion.

Some iron band gabions (galvanized iron) invented by Quartermaster Jones of the Royal Engineers, have attracted a good deal of attention. They consist of bands of hoop-iron about three inches wide, interlaced with light wooden laths, as represented in our wood-cut. The bands are formed into a hoop, and each being prepared for a stud and slot or button and button-hole-joint they are easily put together. This gabion in the absence of wooden laths, can be constructed of rods or wands of any tough wood. Several experiments have been made with it in England, but it has not yet been adopted in the service, the splinters from the iron-hoops being considered a source of greater danger than

the shot of the enemy. On the inner slopes of an earthwork they might render good service, with less danger to the defenders. A bridge constructed chiefly of these bands is represented by a photograph of one actually built as an experiment. This bridge consisted of eight belts or suspending chains of hoop-iron, connected lengthwise by swivel screw joints. Upon these chains or belts was laid a floor of timber planking. This experimental bridge was 100 feet long and eight feet wide, and had a deflection of four feet three inches. It required 672 bands disposed, as stated, in eight bearers, twenty-one bands in length, and four in thickness; and 352 bolts nuts and washers were employed in its construction. The weight, including superstructure, was 5,067 pounds, and the breaking weight nineteen tons. It was constructed by two non-commissioned officers and thirty-two men, in six hours, and was, on the whole, considered sufficiently satisfactory to be adopted in the engineering branch of the service. So materials for several bridges of this sort, with suitable anchors, form part of the regular equipage of the British Army.

Near by stands an Armorer's Field Equipage, with forge and vice-board complete, the whole not occupying more than 5 × 3 feet of superficial space. The tool-chests are evidently contrived for convenience of transport, being only about twelve or fourteen inches deep, about two feet wide and three feet long.

The adjoining case contains a complete display of the fire-arms manufactured at Enfield: it not only includes the various service guns, converted on the Snider system, but specimens in the rough and finished of the several parts of each, with the necessary tools for their manufacture. These parts being identical in each piece render the duties of the armorer, who is supplied with them finished, comparatively easy. Perhaps in no country but our own is this adherence to systematic construction so rigidly followed as in England. But long before the division of labor which such system implies prevailed in the mannfacture of clocks and other wares in America, it had taken deep root in England, where, over a century ago, it took ten men to make a common pin. The same range of show-cases contain model figures dressed in the several uniforms of the service, among which, is one of

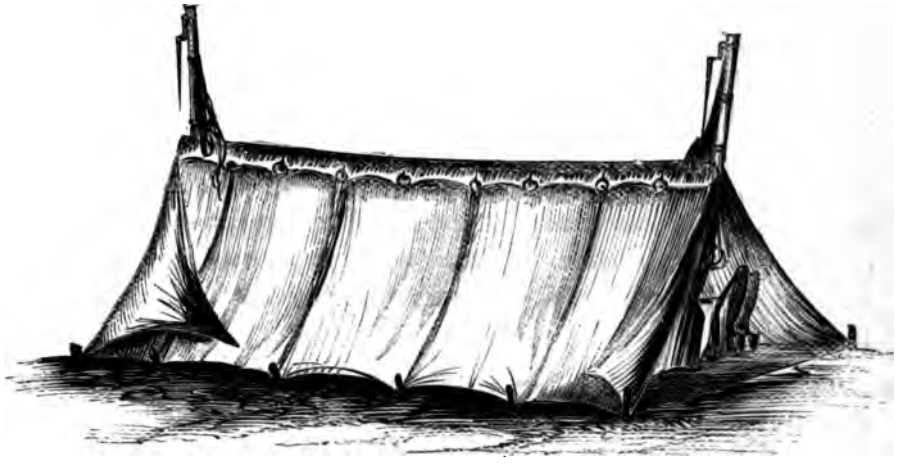
white linen for native Indian and other troops located in tropical climes. It has a cheerful appearance, and in countries where long spells of dry and warm weather prevail, this uniform will be highly prized; still, in variable climates, like that of most of the Southern states, especially during such campaigns as those which our troops passed through in the late war, it would soon lose its spotless whiteness, while it would be inferior for the bivouac and camping out to colored woollen clothing.

In the matter of tents, there is nothing specially interesting in the British Section save a hospital tent, which, for completeness, and the protection and comfort it affords to its inmates, has no superior on the Champ de Mars. This tent is double throughout, with ventilating apertures, so arranged, that, while they admit of a free circulation ot air, effectually keep out the rain. It is similar in shape, though somewhat larger than the double tent used in the U. S. service. Indeed, the chief difference consists in the *roof* only of the latter being double, while this is double throughout. Still, it is not much heavier than the American tent, when the latter is made in two halves to lace together, the extra ends almost make up for the canvas necessary to make the double sides of the English tent.

The speedy recovery of the sick, and consequent increased percentage of effective troops, depends in a great measure on the completeness of the hospital arrangements. For, results of an enlightened treatment of the sick during a campaign will be subject to the same laws that govern like matters in permanent quarters. In 1857 the British Government appointed a Royal Commission, to inquire into the sanitary condition of the army, and they found that, "In England the proportion of men constantly sick is, at certain stations where improved constructions have been adopted, less than half the average number under treatment before accommodation was provided on the scale now considered necessary."

Before, however, entering directly upon the sanitary phases illustrated in the Exhibition, a neat and convenient field or bivouac tent deserves to be mentioned. It is formed with the cloaks of the two soldiers who are to sleep under it. The material of these cloaks is a firm waterproof linen cloth, dyed

blue, and has the appearance of the blouses worn by the French day-labourer. The ridge of the tent (of which we give a wood-cut) is formed by buttoning the edges of the cloaks together. The other edges are fastened to the ground by pegs, and the tent is kept up at each end by she soldier's musket or sword. This simple and unique contrivance which provides a roof in a rainy night to every soldier, has been awarded a medal. It forms part of the collection of the Government of the Netherlands.



Soldier's Cloak Tent.

The French army tents, like the British, are bell-shaped (*tents abri*) with the eaves pinned to the ground; they are generally constructed for eight men, and cramped quarters they make owing to the want of head-room. The French also show a store tent, with racks for bread, which while they keep it off the ground, and out of the reach of creeping insects would make the bread hard and dry if kept any length of time. Outside of this tent is an oven, the floor of which is the natural surface of the ground, faced with a coating of clay. The sides and roof, about 13 inches from the ground, are formed of bent sheet-iron, having a door resembling an ordinary stove-door, but rather larger.

In the private British section, Mr. Scott Tucker exhibits a shortened bayonet for which he claims the following advantages: —First, that it is lighter than the ordinary bayonet, second, it is

not so liable to the annoyance of "crossing," and third, that it can be carried in front, and consequently will be more easily got at in action. The first advantage is merely of value in the sense that "every little helps," for the entire weight of the present bayonet is only about a pound, while its length, in loading with fixed bayonets, will not be any detriment to breech-loaders. Scott Tucker's bayonet is about half the length of the one now used, "and," he says, "is in good hands, long enough for all practical purposes."

An improvement that promises greater relief to the soldier, (not exhibited in Paris however,) has been tried in the British Army and pronounced to be eminently satisfactory. It relates to a new way of carrying the knapsack and accoutrements, which will probably be introduced in connection with the substitution of breech-loading for muzzle-loading small arms. [See woodcut.] A committee was appointed to inquire into the effects of the present system of accoutrements on the health of the infantry soldier, and in their Report as noticed in the *Standard*, they state:—

"That recent campaigns, especially the Bohemian and Italian of 1866, show that it is of the utmost possible importance to husband in every way the marching power and endurance of the soldier, whilst the introduction of the breech-loading system compels the soldier to carry an increase in the amount of ammunition, in consequence of the greater rapidity of the fire which takes place. The latter necessity of course must involve an increase of the weight already carried, unless some special counteracting provision be made. The committee set to work to reduce the weight of the carrying apparatus (knapsack) as much as possible, and to distribute the weight absolutely required to be carried in such a way as to give the muscles of the chest wall and all the shoulder full and free play. The weight that a soldier is compelled to carry, irrespective of the carrying apparatus, the rifle, the havresack for provisions, water-bottle, and blanket, varies from 20lbs to 23lbs, and is made up as follows:—The kit (whose contents differ from those of the old one, by the omission of trowsers and blacking), 6lbs. to 7lbs.; the greatcoat, 6lbs.; ammunition, 90 rounds (the fullest amount required), 9lbs. to 10lbs.; the canteen, 1½lbs.; the bayonet, 1lb., making a total of from 22lbs. to 24lbs. On ordinary occasions less ammunition might be carried. The weight of the carrying apparatus has been reduced from 10lbs. 2oz. to 4lbs. 3oz. Now as to the mode in which the kit is recommended to be carried: the old knapsack is discarded, and

Soldier's New Kit-Bag.

in place of it a bag is introduced; this is placed low down, and suspended from a leather yoke, similar in principle to the valise proposed some time ago by Sir T. Trowbridge. The weight of the kit-bag is distributed in three directions—(1) the yoke, by means of straps passing before and behind to studs on the yoke; (2) to the large bone connecting the two hips; and (3) to the belt, by means of additional straps. The weight of the ammunition is also distributed."

The committee have recommended the use of two long and narrow pouches, each capable of holding 30 rounds, and made of soft leather. In time of peace one only would be worn, exactly in front of the waist-belt, and suspended from the yoke. In time of war two would be worn, and, in addition, two small pouches in the kit-bag for ten rounds each, have been made, and these might be filled, and ten more loose rounds would be contained in a little bag worn on the right side. The greatcoat is worn on the back, and strapped to the yoke. The new carrying apparatus, at all events, is about 6lb. lighter than the old knapsack, and as far as the health and comfort of the soldier is concerned the novel mode in which the weight is carried offers an immense advantage over the old system in every way.

In the matter of signals and army telegraphy, the Austrians make the best display in the Exhibition. The advantages derived from the use of the telegraph during the Franco-Italian war of 1859, and during our own civil war, has led to the organization of telegraph trains, in most of the European armies, and to the adoption of equipments specially suited to army telegraphy. Of the collapsing drum, the cone, the shutter, and other well-known devices for signalling by daylight, it is not our intention to speak. The Austrians exhibit a signal apparatus, which consists of a pole about 20 feet high, having three discs of about nine inches in diameter arranged in the form of an equilateral triangle at the top. The two lower discs are moved by one handle, and the top one by another so as to turn either surfaces or edges to the front. The messages are transmitted by displaying surfaces or edges in different positions. It is claimed that the use of three discs facilitates the communication, but, on the other hand, an alphabet different from the Morse, or other telegraph alphabet in

common use, has to be employed. They also exhibit drawings of a lamp with a Drummond light and reflector, which is intended to illuminate the ground surrounding the point of observation. The lighting up of Fort Sumter, at the distance of a thousand yards, has led some military authorities to believe that this will be an effective apparatus of great value during siege operations, to the defending, as well as the attacking parties. But though a stream of light can be turned for a long period on a given point, the source of the light will always form a good mark for the guns of the enemy, whilst a parachute light-ball, like that previously described, if it only burns for a few minutes, does not reveal the position of those using it.

In electric telegraphy for war purposes, the Austrian Government, are the most extensive exhibitors, but though they show, in apparatus and drawings, various examples of their telegraphic equipment, they did not use them in any case during the late war with Prussia. They have hitherto been used only experimentally. The equipment, though light and portable, cannot be got into working order without considerable loss of time. The following extract from an able article in the London *Standard* will sufficiently explain the working arrangement :—

"The central station is contained in a handsome, yellow-painted square carriage on four wheels, and harnessed for four horses, very like a small light omnibus, the interior of which is fitted up as an office, with writing-table, pigeon-holes, and other conveniences, and into which the terminals of all the lines in communication are brought, and from which dispatches to all out-stations can, of course, be directed by the chief operator attached to the staff; the main object of the field telegraph being to maintain the head-quarters of the Commander-in-chief in constant communication with the telegraph of the State. The requisites are well-horsed carriages, portable instruments, and a trained staff for the erection, manipulation, supervision, and demolition of the field lines. The principal carriage station is a regular telegraph office, from which the service can be commenced as soon as the line is finished, and wherever it may find itself. Nevertheless, these carriages have been latterly abandoned on account of their weight, and, only apparatus is taken, an office being established at the first place affording sufficient shelter. The Austrian authorities lay great stress on the maintenance of a military telegraphic corps, as possessing the triple

advantage of constantly increasing the degree of perfection of military telegraphic proceedings—of familiarising the army to this novel branch of warfare, and of obtaining also under the fire of the enemy, results which could only be exacted from soldiers, and never from civilians.

The apparatus adopted is the magneto-electric instrument of M. Markus, of Vienna, and is considered to present this double advantage—that the telegraphic communications take very little time in transmission, and that it is itself very portable and does not require any fluid battery.

The field-lines, consisting of gutta-percha covered copper wire, are wound round the drum fixed to a small hand-carriage, mounted on two wheels about a yard in diameter, and the frame of which, about five feet long, has a folding leg, upon which to be rested when not in motion. There is also a V-shape guide-wheel for keeping the wire central in paying out and winding in. Two men serve the machine. The field telegraph is a magneto-electric apparatus, with alphabetical dial and index-handle, of familiar construction, and a receiver beside it on the same table, which is formed by the box enclosing the apparatus. This box stands on two folding legs, and a portion of its side opens out horizontally into a seat supported on one folding leg for the operator. One side of this seat is padded, so that when the whole affair is folded up compactly the porter or soldier may carry it more conveniently by straps coming over his shoulders. A large umbrella with long handle is provided for sticking into the ground, and forming a sort of tent or shelter for the telegraph operator. The poles for elevating the field-lines from the ground are carried in horsed waggons, and a sort of large iron crow-bar is provided for making the holes for their insertion. In general half a day is considered necessary for setting up a length of two Austrian leagues (1½ myriametre, or about 9 miles); but, under favourable conditions—firm flat ground, and without obstacles, and with strong trained soldiers—this may be done, it is said, in two hours. The insulators are bell-shaped cups of india-rubber fixed on to iron forked vertical staples, the arms of which are attached to the posts; over the india-rubber is pushed a cap of glass round a ring in which the wire is twisted."

The Austrians also use a Morse recorder, with clockwork in a compact form. Recording instruments possess advantages over most of the European methods in accuracy and speed, as well as in the more important particular, of leaving a record of the message. The greater responsibility which devolves on the operator when messages are recorded, tends to care in their transmission, and in military telegraphs, especially, this is most important.

The advantages of telegraphy in the field are incalculabl
lines of wires are properly laid, the head-quarters of any one c
or army can, through the network of wires, be placed in r
communication with any corps at a distance, and thus, the gre
of the evils consequent on the separation of two parts o
army, the ignorance of each other's movements, may be avoid

CHAPTER VII.

SANITARY EQUIPMENTS.

THE Sanitary Equipments exhibited in 1867, evince a great advance in this philanthropic direction, as compared with any past exhibition. The efforts of the U.S. Sanitary Commission during the war, and the admirable collection of Dr. Evans at Paris, render any lengthy notice of these matters unnecessary in this Report. The American Collection is supplemented, but not excelled, or even equalled, by that exhibited under the auspices of the "International Society for the relief of the Wounded," ("La société de secours aux blessés Militaires des Armée de Terre et de Mer.") The society originated in suggestions arising from the insufficiency of the military arrangements for the relief of the wounded during the Italian campaign of 1859, and more especially at the battle of Solferino. It is guided in its operations by the principles laid down at an International Conference held at Geneva in October, 1863, and by the regulations embodied in the Convention of 1864. The Conference of 1863 was brought about by a Committee of the Société d' Utilité Publique, of Geneva, of which M. Durant, the author of a work, entitled "Un Souvenir de Solferino," was the promoter and secretary. It contemplated the formation of national committees to minister to the necessities of wounded soldiers, and to supply and maintain, in time of war, volunteer attendants in aid of the military administration of armies in the field.

The Geneva Convention of 1864, has facilitated the working of these committees by establishing the neutrality of field hospitals, equipment, military hospitals in actual use as such, and of the sick and wounded therein. It also provides that the hospital attendants and the *personnel* employed in the transport of wounded shall, while non-combatant and solely occupied in these duties, partici-

pate in the neutrality. Private houses, devoted to the accomodation of wounded are also to be respected, and inhabitants who assist the wounded are also to be protected and exonerated from a share of the contributions of war, which may be imposed. It was part of the project of the originators of the movement, to give the national committees a status during a campaign, independent of the military administration; but this suggestion was likely to be attended with so much inconvenience, and gave rise to so many objections, that it was not noticed in the Convention, which only recognizes the neutrality of *military* hospitals and their *personnel*, including, of course, the volunteer attendants acting under military regulations, and officially recognized by the General Officer in command of the army.

All the great European Powers have now signed the Convention, and the fact that within the last year Austria, and within the last month, (July) Russia, have become parties to it, would appear to prove that its principles are consistent with the autocratic military system. The medical regulations of the French Army, contemplates the assistance of the "Société de secours aux blessés Militaires," in aid of the military administration. Acting on resolutions agreed to at the Conference of 1863, national committees of the societies were formed in most of the European States, and those of Prussia, Austria, and Denmark were called upon to practically perform their functions during the campaign of 1865. The good results attending the operations of the Prussian Committee during the campaigns of 1865-66 have gained for it the special patronage of the Government, the Queen and Crown Princess taking a personal interest in the subject.

The committee, besides furnishing each army corps with a proportion of volunteer nurses (more than 600 Prussian ladies acted as such), procured with funds raised by voluntary subscriptions supplies of medical comforts, dressings, &c., to the value of over two millions of francs. These supplies were periodically dispatched under the personal direction of members of the society, to the different theatres of war, and were there dispensed to wounded and sick soldiers without distinction of nation.

It has been estimated by some that the lives of 40 per cent. of

those who have perished on the field of battle in recent wars—many from thirst, hunger, or cold—could have been saved, had it been possible to remove them without delay to places where their wants could have been attended to in safety.

The exhibits of ambulance equipments to accompany an army in the field, comprise medicine-chests, medical appliances, instruments for medical officers, stretchers, litters, cacolets, ambulance conveyances, etc., of patterns which have been used during the late European and American wars, as well as others shown by the French and English Governments, and by manufacturers and persons interested in the subject.*

The several articles may be classed as follows:—

1. The appliances for dressing wounds on the field of battle, and for the removal of wounded men to the field hospitals, which are usually established immediately in rear of the armies engaged.

2. The equipment of field hospitals or "ambulances," and the conveyances specially constructed for the removal of sick and wounded during the march of a column, or to a fixed hospital or ship.

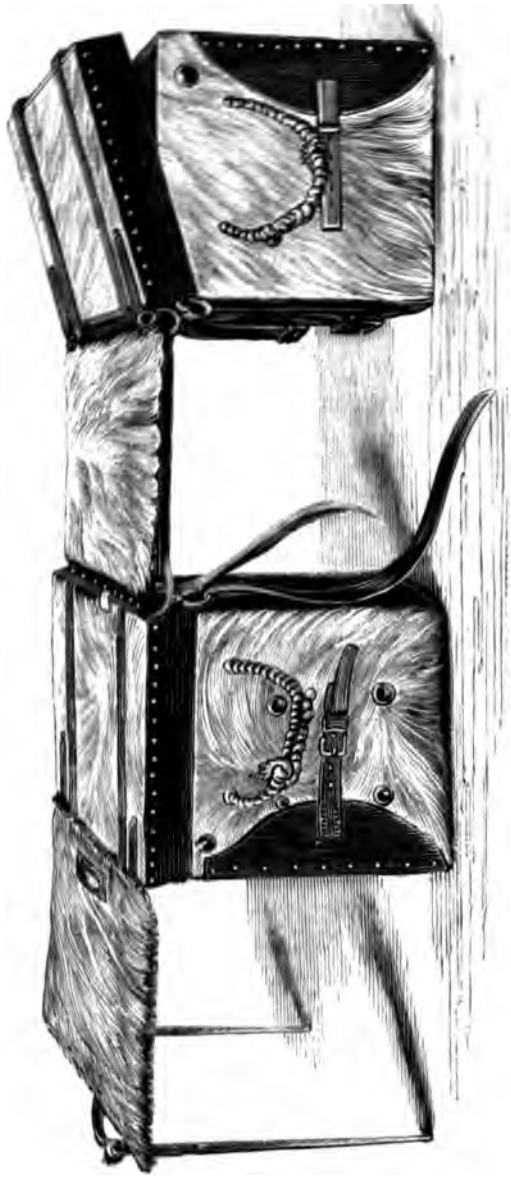
3. The means for removing sick and wounded from temporary to general hospitals by railway and other land conveyances.

Count F. de Breda, one of the secretaries of the "Société de secours," having carefully studied the equipment in use in the French and other armies, has also collected, for the consideration of the international committee, a large number of objects of the patterns which appeared to him to be most worthy of consideration.

The panniers in Count Breda's collection have been arranged by Mr. Arrault. Each is complete in itself, and besides instruments and medicines, contains dressings for 250 wounds; the linen, lint, &c., being compressed so as to occupy about half the space usually required. The cases are made of wicker-work and covered with leather. They are lighter than wooden canteens, and they afford more security to the contents. It is said that one of those exhibited has been thrown from a second-floor window

* From a valuable paper by Major Leahy of the British Royal Engineers, we select a description of some of the most interesting exhibits in this class.

without injury to the bottles therein. The weight of each pannier complete is about 90lbs.



British Field Medicine Chest.

In addition to the panniers Mr. Arrault has arranged knapsacks

to contain the dressings, etc., more immediately required on the field of battle, and intended to be carried by the hospital attendants of infantry regiments. The knapsacks weigh 16lbs., and contain dressings for fifty wounded.

There are several examples of field medicine-chests exhibited, but attention is more especially directed to the two army medicine-panniers exhibited by the British Government [see woodcut] and to the model pannier proposed by Count Breda. The former are baskets covered with hide, and together contain a very complete assortment of medicines and of medical appliances and comforts. The contents are conveniently arranged and securely packed, but they have not been selected with special reference to the requirements of the wounded. Bottles containing poisonous drugs are constructed so as to be readily distinguished from those holding more simple preparations. The panniers will form an operating-table. Their weight is 180lbs. In connection with them is shown a "Medical Field Companion," a kind of pouch containing a small assortment of medicines and dressings. The weight of this pouch is 11½lb., and it is intended to be carried by hospital attendants.

Among the instruments for which merit is claimed is a "coupe-botte," or knife for cutting off the boots of men wounded in the foot.

For the removal of wounded from the field of battle a great number of contrivances have been proposed and exhibited; but a large proportion are wanting in qualities desirable for the purpose. There is no one example which combines all the conditions necessary to produce a good litter, and which may be stated to be—

(1) Simplicity of construction, with means of taking to pieces, so as to facilitate transport and the replacing of damaged parts.

(2) Lightness, so far as is consistent with strength; capability of being carried by one man.

(3) Means of placing the appliances on wheels, with good springs or suspension, so as to travel over rough ground with easy motion, and thereby facilitate and expedite the removal of wounded.

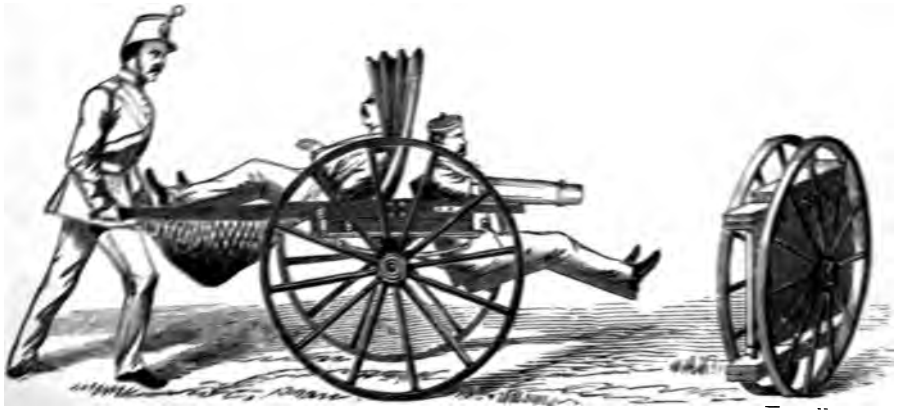
(4) Cheapness and durability.

A stretcher in the British section is exhibited by Mr. George

Bedford, the poles of which are in short lengths, and are put together like the joinings of a fishing-rod, but on the whole, the common stretcher (consisting of two poles and canvas sacking), used in the British and American armies, appears better adapted to field service.

No litter, however, can be satisfactory which requires two men for the removal of one: and attention is now being directed to wheeled litters, by means of which the wounded may be removed, more rapidly and with less fatigue, by half the number of men required for carrying the ordinary stretchers.

In the Prussian section of the "Société de secours" collection is shown a wheeled litter, constructed by Messrs. Neuss, of Berlin,



Neudörfer's Wheeled Litter.

which was used in the campaigns of 1865-6, and which is made of canvas stretched between two light wooden poles, and placed on springs affixed to an iron axle. The side poles are provided with handles at each end, so that the litter may be drawn, pushed, or lifted. It is provided with a hood to form a protection against rain, and props are attached to the poles by means of which it can be supported in a horizontal position when at rest. Litters of this pattern were used to transport wounded from Düppel to Flensborg (a distance of about twenty-five miles) in 1865, and it is said that a number were supplied to the French army in Mexico, and were there considered to have advantages over the mule-litters used in the French service. The litters of Messrs. Neuss are light

(weight about 110 lbs.), but do not admit of being packed in a small space, and are not so simple in construction as desirable.

A wheeled stretcher will be found in Count Breda's collection, but it has no springs, and admits of many improvements in detail.

Messrs. Fischer and Co. exhibit a wheeled litter which will carry two men—one lying, the other sitting. Conveyances of this kind (see engraving,) were proposed by Dr. Neudörfer, an Austrian military surgeon, and were used, it is said, with success in the Schleswig-Holstein campaign of 1865. The example shown appears to be too complicated and expensive for military purposes, and it would not be easy to place a helpless patient in it. It is more economical in labour than Neuss's litter, and if the construction could be simplified might, doubtless, be advantageously used.

The British War Department show a jointed stretcher with hood, which can be also used as a chair, or bed. This, if placed on wheels, would be a good type of litter. In ambulance waggons there is a great variety. The French Government show two ambulance conveyances now in use experimentally—viz., a two-wheeled cart, weighing 650lbs., intended to be drawn by one horse; and a waggon, weighing 2,050 lbs., to be drawn by two horses.

The use of two-wheeled carts is attended with disadvantages, which render it undesirable to adopt them in a model ambulance equipment. In the first place, the motion is most unfavourable for the transport of wounded; and, if the cart were to proceed at a pace quicker than a walk, might be intolerable. Secondly, there would be great risk of serious accidents to the wounded if the horse were to stumble or the shafts to break.

The new pattern waggon shown by the French Government is simply a bad omnibus. It will carry ten sitting, or two men sitting, and two on stretchers. It does not appear to possess any of the qualities peculiar to a good ambulance conveyance, and which may be stated to be as follow :—

1. Very easy motion.

2. Convenient arrangement of beds and seats, with sufficient space and ventilation.

3. Facility for mounting and for inserting the stretchers on which badly-wounded men could be placed.

It is also very desirable that the waggons specially constructed for conveyance of sick should be light, so as not to require, under the ordinary circumstances of a campaign, more than two horses: and that they should admit of being easily turned in a small space.

"Of the special conveyances exhibited," says Major Leahy, "some possess the conditions desirable in ambulance conveyances to a greater degree than those used in America, examples of which are shown in Dr. Evans's collection, and in the shed for the exhibition of American agricultural machinery. These waggons are of the character of light four-wheeled carriers' carts, with extra springs and seats to adapt them to the particular use for which they are intended to be applied. It is said that this class of waggon was adopted after the trial and failure of the heavier description still in use in France and England."

There are occasions when, owing to the absence of roads or tracks for wheeled carriages, it is necessary to employ pack-animals for general army transport, and consequently for the conveyance of wounded. This was the case during the first occupation of Algeria, and it is still necessary to have recourse to pack transport for supplies sent to the advanced posts in that colony. In reference to this necessity, the French some years since organised a very complete field ambulance, the stores for which, as well as the sick, are carried on mules specially trained and selected for that purpose. The mule train for an expeditionary column of one thousand men usually consists of forty-nine animals, each led by a hospital attendant or soldier of the train; of these, sixteen are allotted for the conveyance of equipment, and thirty-three for that of sick.

There are two kinds of mule-litters—the "cacolet," so-called from its resemblance to the contrivances used in conveying milk ("caque au lait") and the litiéres. The former is a kind of arm-chair, one being slung at each side of the pack-saddle, in which the sick or wounded soldier sits upright. The second is a couch similarly carried, in which the man lies down, and is protected from sun or rain by a hood.

Examples of "cacolets" and "litiéres" are exhibited by the French Government, by Dr. Evans, and in the collection of the "Société de secours;" but this kind of transport is not looked

upon as a model except in cases where wheeled transport cannot be made available.

The Baden committee of the "Société de secours" exhibits an arrangement for suspending the litters in railway carriages; and M. Locati, of Turin, submits a plan for fitting up a third-class carriage as a hospital waggon. But the most interesting example of this class of conveyance is a model of the hospital railway cars used by the United States Sanitary Commission, and exhibited by Dr. Evans.

The whole of these articles are being examined in detail by an international committee of the "Société de secours," which has been charged with the task of proposing, with a view to its adoption by the national committees, a model equipment, which shall combine the best points of the patterns exhibited and satisfy the requirements laid down by competent authorities. As this committee includes among its members military medical officers delegated by the governments of the principal Powers, it may be expected that military ambulance equipments will be organised on the model which may be eventually approved.

CHAPTER VIII.

FORTIFICATIONS.

THE Exhibition of 1867, taken as a whole, is very complete in all that relates to war on land and sea, with perhaps the single exception of Fortifications. Neither in models, or drawings, can the Engineering branch of the military service compare with the display of small arms, heavy ordnance, or iron-clad ships.

The building, or tent, of the French Minister of War, contains a few models evidently illustrating the wars of former days. The chief of these has a collection of Lilliputian figures, busily engaged in constructing a rough-and-ready wooden bridge, across a little creek filled with *real* water. The bridge is being formed with round logs thrown across the stream, with transverse planking in process of being laid. A model of a fortified valley, though without any details of construction, and several models of barrack buildings are more interesting. But on the great question of fortifications constructed with a view to resist the destructive power of modern artillery, these throw no light. Photographs of Martello towers, and other stone works, in the act of crumbling to pieces under the fire of heavy cannon, are exhibited, but these are evidently meant to illustrate the power of the guns, not the endurance of the crumbling structures, and are doubtless exhibited by the Ordnance, rather than the Engineer department.

In the British section, photographs of similarly battered works are exhibited, chiefly illustrating the trial of the Armstrong and Whitworth seventy-pounder field-guns. With a view to test the power of these guns against stone walls, the Armstrong and Whitworth Committee obtained permission to attack a martello tower, constructed on the Sussex coast in 1804 and which mounted one gun. The report of the Committee says:—

Experimental Granite Casemate.*

* The granite of this work, as will be seen from what follows, literally crumbled away under the impact of cast-iron shot, while the iron shields, though more severely tested by steel shot, continued to offer a fair resistance. The committee who conducted the experiments say:—"Both the iron shields have resisted well, and the fastenings of both may be said to be still effective, inasmuch as they have held them in their places to the last. Those of the cast shield (A) are indeed hardly impaired." The shield B, however, was broken across, and its existence as a defence depended on the endurance of the granite in which it was secured.

"The total height of the tower was 31·5 feet, the diameter at the base was 46 feet, and that of the top 40 feet. The platform upon which the gun was intended to be mounted was carried by a semicircular arch turned from a pillar in the centre of the tower, 4 feet in diameter, to the exterior wall, there being about 5 feet in thickness of brickwork between the crown of the arch and the platform of the battery above it.

The situation of the tower, with reference to adjoining property, was such that conditions of safety precluded the Committee from firing at it from any direction but one. All three guns had, therefore, to be in one battery, which was 750 yards distant from the tower, and as a consequence the portions of the tower allotted to each gun as a target were somewhat different, and as the brickwork varied in thickness at almost every foot of its height, the difficulty of obtaining good results for comparison was very much enhanced. The object of the Committee not being to destroy the tower, but to obtain good relative penetration for comparison, the firing was commenced with common shell filled with sand.

It appeared that these shells fired from both of the muzzle-loaders had sufficient power to pass through the brickwork where it was seven feet thick, the muzzle-loading Armstrong shell being found unbroken inside, and the Whitworth shell in pieces; the shell from the breech-loader penetrated 4·75 feet into the wall where it was 7·25 feet thick, and 5·6 feet into the wall where it was about 6·4 feet thick, cracking the brickwork inside and knocking away three bricks of one course.

A shot from each gun struck on the solid part of the tower where the brickwork is about 40 feet thick; the hollow-headed shot of the breech-loading Armstrong gun penetrated 3 feet; the solid shot from the Whitworth gun passed through 7·25 feet of brickwork, having deflected downwards and broken through the crown of the arch; the hollow-headed shot from the muzzle-loading Armstrong gun penetrated 4·75 feet. All the measurements of penetration where the projectiles did not pass through the wall were taken to their bases.

Only one live shell was fired from each gun with results which were capable of comparison, after which the tower became so injured that the amount of damage attributable to each round could not be recorded."

The chief attraction, however, in the British section, connected with fortifications, is the series of photographs which illustrate the trials of the Experimental Granite Casemate at Shoeburyness in 1865. The following illustrated account of this experiment, is abridged from Humber's "Record of Modern Engineering:"—

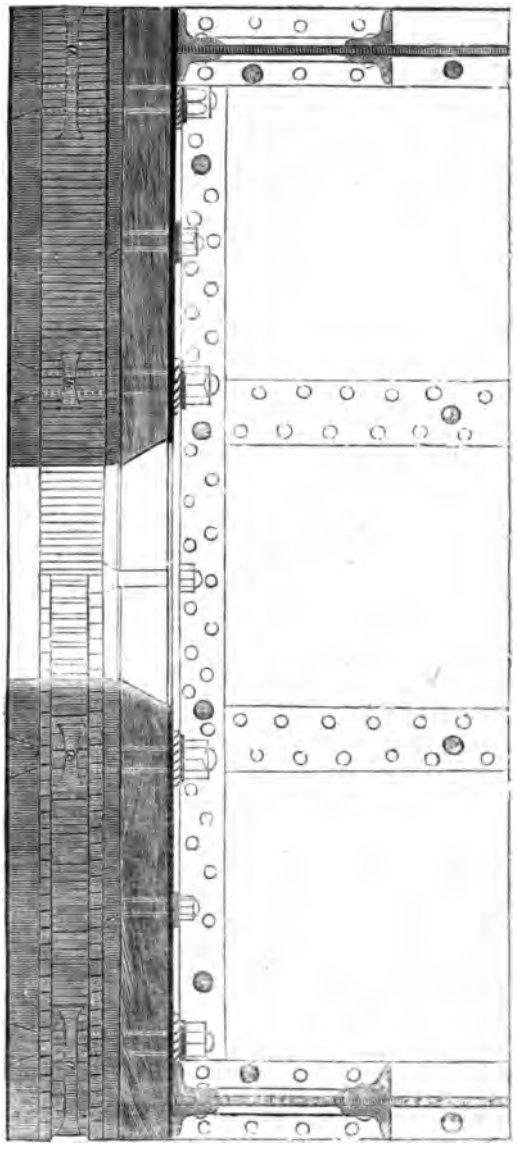
"The trial of the Granite Casemate, represented in Fig. 1,

commenced on the 16th November last, and was conducted by the Ordnance Select Committee, assisted by Col. Jervois, R.E., and Major Inglis, R.E., Superintendent of Works at Shoeburyness. This structure with its area of about 1,500 feet, presented five distinct feaures or combinations to the guns. First, the granite work; second, the compound shield A (Fig. 1); third, the solid-plate shield B; fourth, the right or east wing facing, C; fifth, the left wing facing, D. The granite work was composed chiefly of masses of stone of from eight to ten tons weight each. Some of the courses were three feet in thickness, the stones being eight or ten feet in length, and from four to five feet in width. The entire thickness of the granite wall, including a two-feet lining of brick-work, was fourteen feet.

"The shield A, for the large embrasure, 12′ × 8′, was made at the Regent's Canal Ironworks. It had a front plate of four inches thick, and a backing of thin iron plates eight inches deep, their outer edges supporting the front plate, and their inner bearing on a second armor-plate of two inches in thickness. This, again, rested upon a cushion of teak timber six and a half inches thick, the whole bearing on a skin of inch-iron, and bound together by 22 bolts* of three inches diameter, and 16 bolts of two inches, all having shallow square threads. The skin was attached to two struts by double angle-bars 6″ by 4½″ by ⅝″, and strengthened by six similar bars running at right angles to the struts. A strong H girder, 18 inches deep, strengthened the shield across the top of the embrasure. The struts to which the shield is attached rested upon a bottom plate of inch-iron, three and a half feet wide, and through this plate the entire mass was secured to the stonework by 10 bolts of 2½ inches diameter. The backing bars, where cut to admit the passage of the through bolts, were bound together in bodies by the rivets *a*, Fig 2. This shield owed its origin to the successful trial of the Chalmers target in April, 1863, and the recommendation of Lord Palmerston, who introduced the inventor

* These bolts were made of Lowmoor iron, which is too much like steel in its nature, and not sufficiently fibrous to stand the vibration caused by the impact of heavy shot.

to the Secretary of State for War. As originally proposed, the principle was the same as the Chalmers target; but at the suggestion of the late Iron Plate Committee, and the Engineers of the War Department, it was altered to the form represented in the accompanying diagram. For the compound backing, or alternate layers of timber and iron of the original design, the present backing of layers, all of thin iron, was substituted, on the ground that it was not advisable to introduce such a perishable material as timber in a permanent work. Half of the shield, therefore, has a backing of plain bars 8" by 1", and the other half has bars which match or bind into each other. The latter were suggested by Mr. Chalmers, and their adoption for the entire shield would only have added about £10 to its cost. These alterations, while they still leave a cushion of timber in the very heart of the structure, add



Chalmers's Shield, Sectional Plan.

FIG. 2.

great as the weight and cost of the shield without improving its power of resistance. This shield has cost over £1,000, independent of the consideration paid to Mr. Chalmers for the invention and superintending its construction; but a shield of the same size, on the plan originally submitted (which has been proved to offer greater resistance to shot), would have cost only a small fraction of this amount.

"The wrought shield B, designed by Major Inglis, R.E., Superintendent of Works, was manufactured by Messrs. John Brown & Co., of Sheffield. It was simply a solid plate of 13½ inches in thickness, with a porthole 3 feet by 2ft. 4in. It had no fastenings or backing. At top and bottom it was let into the stonework about 6 inches; and in order to keep it up to its work, it was further supported by bars of railway iron embedded in the stonework, which was fluted to receive them. The right flank of the casemate was protected by the cramped iron-facing, C, generally termed "the puzzle," because the pieces of iron bind into each other in the manner of certain puzzles made of wood for the amusement of children; and the left flank, D, was protected by 4½-inch armor plates, backed with timber and concrete. The entire cost of this experimental structure, including cost of trial, was about £8,000. The battery to test the structure was placed at 200 yards distance, and consisted of the following guns:—

7-inch shunt, throwing a steel shot	115 lbs.	with	18 lbs.	ch.
8-inch M. L. gun	„	150 lbs.	„	22 lbs.	„
9½ „	„	„	220 lbs.	„	30 lbs.	„
10 „	„	„	280 lbs.	„	36 lbs.	„

"The latter charges were increased to 41lbs. when firing at the compound or Chalmers shield A. Against the stonework cast-iron shot only were used.

"It is not necessary here to give a detailed account of the firing. The following graphic account, from an able article on "The Spithead Forts," in the *Saturday Review*, gives a correct summary of the results of the experiments:—

"'The experiments were directed to two distinct objects—first, to test the comparative resisting power of the two shields; and secondly, to ascertain how long the huge mass of granite would be able to stand the

fire of the formidable battery. In order to approximate more closely to the conditions of a probable attack, the charges of the guns were reduced, so as to give the same striking velocity as if they had been fired at 1,000 yards—a precaution somewhat lenient to the fort, though, as the result proved, not sufficiently so to save it from destruction. The practice on the shields exactly accorded with previous experience. The solid plate was seriously damaged, and a few more shots would have knocked it fairly away.* The Chalmers target stood well, as it has always done before; it kept out all the shots, and suffered no great injury beyond the snapping of several of the bolts. The battery was then turned upon the masonry, and though only cast-iron shot were used, the first blow fairly split a huge mass of granite far in the rear of the point of impact. Still the shot did not get through, though the ultimate fate of the structure might easily be foreseen. Two rounds from the four-gun battery were then completed. Of the eight shots, one missed altogether; but the other seven struck the granite walls. Upon examination, it was found that a great part of the casemate was a heap of ruins, and that one of the shots had forced a clear passage into the interior of the work. The conclusion is that seven well-directed shots, from a range of 1,000 yards, will suffice to annihilate the projected Spithead Forts, and that all the labour and money bestowed upon the works will have been thrown away, unless some better material than granite can be found for their construction. . . . . It seems pretty clear that the granite gave way, less from the destruction of its face than from the want of elasticity which made the whole mass crack and fall to pieces under the blows to which it was subjected. An iron facing,† unless backed by wood and converted into armor strong enough to need no further backing, would do very little to break the shock upon the inner wall of stone, and there is scarcely room to doubt that the first experiment upon it has finally settled the fate of granite as a material for a first-class fort. If it were certain that this conclusion would be accepted without reserve and without delay, there would be nothing to cause alarm in the failure of this first design for our harbour fortresses, but it is sometimes easier to demolish the stoutest material than to batter down a preconceived idea. Perhaps in this particular instance the failure of the proposed design has been too conspicuous and too startling to be altogether without effect.

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* "The thick-plate shield, which was virtually disposed of at the fourth round, was struck by a total of 765lbs. of metal, propelled by 106lbs. of powder; whilst the bulit-up, or Chalmers's shield, resisted 2,445 lbs. of metal, and 311 lbs. of powder."—*Army and Navy Gazette.*

† Such as the right and leit wings C and D of Fig. 1.

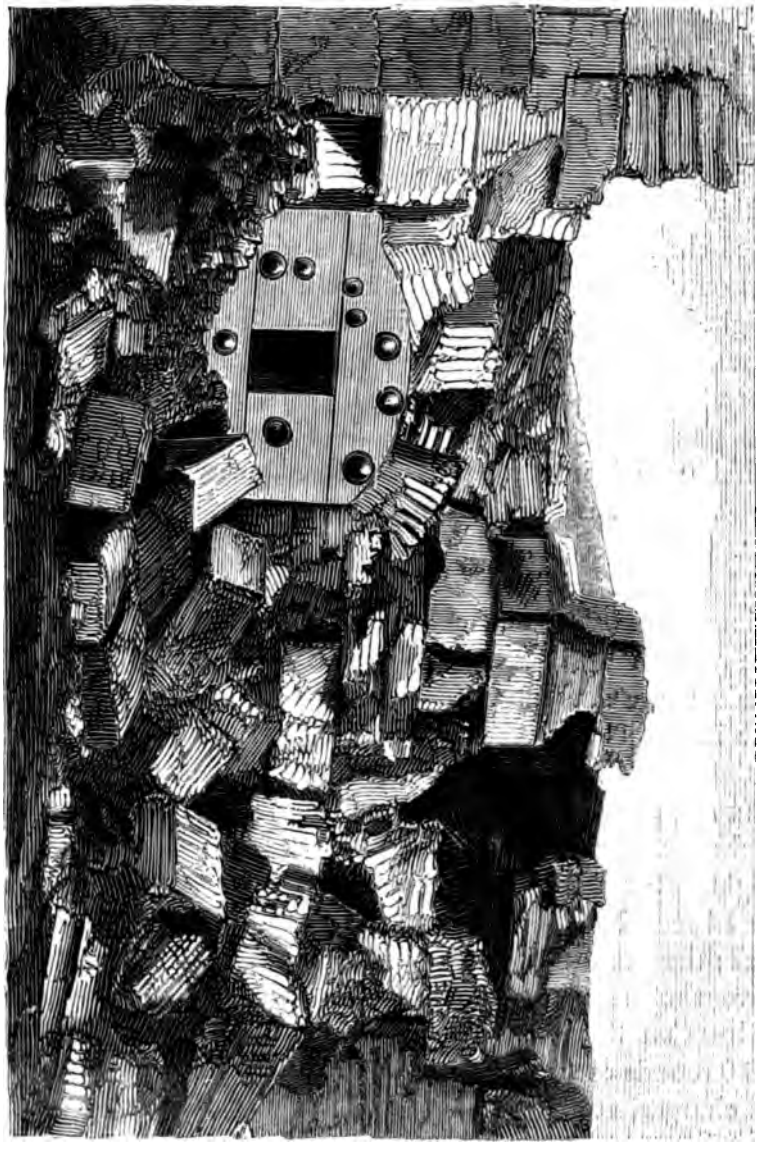
It is scarcely conceivable now that the defences of Portsmouth will be actually built of a material so worthless as granite has proved to be; but it is quite possible that the cause of Iron *v.* Granite for the defence of forts, may be as tedious as the cause of Iron *v.* Wood was in the construction of ships. In all these matters the rule seems to be to cling to an old prejudice until it is fairly battered to pieces, and we only hope that the moral resistance of the granite theory may prove as feeble as the physical resistance of the material itself.'

"Granite having been thus effectually disposed of as a material for forts, the superstructure of the works at Spithead will probably be chiefly of iron; in which case, reason, science, and all past experiments alike suggest that a large portion of the material should be composed of plates having their edges opposed to the attacking projectile. An arrangment similar to that of the Chalmers Shield, or perhaps a compromise between it and the 'Naval Armor,' by the same inventor, referred to in The *Record of Modern Engineering*, 1863, could doubtless be extended to the entire walls of these forts, with advantage as regards resistance to shot, and economy of space, if not of cost, as compared with granite."

The "arrangement" suggested in the closing paragraph of the *Record* article, had previously been brought forward and submitted to the English, and other goverments by Mr. Chalmers. It consists mainly of a double series of iron plates placed edgewise and running at right angles to each other. The inner series alternating with planks of timber and the outer composed of H-girders forming cells which are filled with asphalte. When used as a facing to protect stoneworks already constructed, it is proposed to use only the front layer and the second plate, with a cushion timber between them and the stone-face; when the system is to be adopted for shields to protect a gun mounted in a stone casemate, or in earthworks, the above method is to be applied in its entirety. The following description from the London *Standard* of certain experimental structures now being erected at Shoeburyness, will show that this system has been received with favor by the British Fortifications' Department:—

"The brick and granite walls are covered with 4½-inch plates

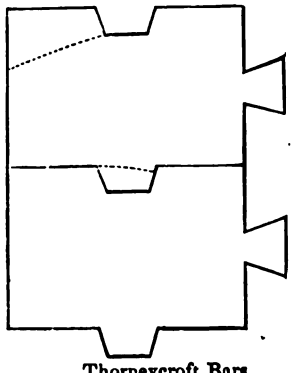
about 12 feet long and 3½ feet wide, backed by four girders made of angle-iron and H-plates, concrete about 5 inches thick being



Granite Casemate after 40 rounds of cast-iron shot, averaging 190 lbs. each with an average charge of 20½ lbs.

run in between the plate and the girders." The system here

perhaps, by the conclusions arrived at during the earlier stages of the English experiments, namely, that the resistance of certain plates would be to each other as the squares of their respective thicknesses, the Russians have hitherto used plates and bars of great weight and thickness. One system, known as the "Thorneycroft bars," has been used to some extent at Cronstadt. It consists, of bars of iron 15 inches wide and 10 inches thick, which have been rolled with a groove and a tongue, and built up so as to form a wall of iron 15 inches thick with dovetail fastenings in the rear as illustrated above.



Thorneycroft Bars.

So long as structures of this description were subjected to comparatively light tests, which was the case when the Russians adopted them, they were considered to be sufficiently strong and economical. But when they were attacked by projectiles possessing *energy* or *work* equal to 2,000 or 3,000 foot-tons, they gave way at the tongues (as shown in dotted lines), and the bar or bars struck invariably opened at the back, thus destroying (almost in the same manner as in the disintegration of granite under impact) the cohesion of the structure.

In order to get rid of that bugbear of military engineers—a *wood-backing*—the Russian engineers, in another work, had recourse to solid wrought-iron plates of great thickness. One of these plates, about fourteen feet long, four feet wide, and eleven inches in thickness, manufactured by Messrs. John Brown and Co., of Sheffield, was sent to Shoeburyness to be tried. It was attached at the ends to a strong framing in order that it might be fired at without backing, the belief at the time being that the plate would be of sufficient strength unbacked. A 13½-inch gun was laid at the centre of the plate, loaded with a solid spherical steel-shot of 360 lbs. weight, and a charge of 70lbs. of powder. The shot, with a *vis viva** of about 3,750 foot-tons, struck the

* The *vis viva* of a body in motion is the whole mechanical effect which it will produce in being brought to a state of rest, without regard to the time occu-

plate fair in the centre, when the calculation, that the plate would resist penetration, was fully verified. But another result not calculated on followed. The plate, though it arrested the progress of this single shot, was split from end to end by the blow, both halves being torn from their fastenings and one of them thrown several yards away from the other, as if it had been a chip of timber, leaving exposed the work they were intended to protect. Had this target consisted of eleven superimposed inch-plates, it would doubtless have been more easily penetrated *(if unbacked)*, but it could not thus have been so easily torn away from its fastenings. There seems to be little doubt that laminated plates supported by a compound backing, like that of Mr. Chalmers, would give a very effective protection to stone-works, and at much less cost than any system which requires heavy, and consequently expensive, forgings. Assuming the eleven-inch solid plate, upon a backing of fifteen inches of timber, to be a sufficient protection against the heaviest ordnance in existence, let us see what probable protection (and at what comparative cost) could be obtained by a like weight of inch-plates disposed in the manner adopted in our ironclads and supported by the system of backing exhibited by Mr. Chalmers. These structures [see woodcut] are of the same weight and depth of materials, and their respective costs, to cover an area of 10,000 superficial feet, would be as follows:—Each would require 2,200 tons (of 2,000lbs. per ton) of iron. The plates of

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pied, and it varies as the weight of the body multiplied by the square of its velocity. This mechanical effect, or "work," accumulated in the moving body is represented by the weight which it is capable of raising 1ft. high, and is equal to the weight of the moving body multiplied by the square of its velocity, and divided by twice the force of gravity—

or $$\frac{W\,v^2}{2\,g}.$$

Thus if a shot of 165lbs. weight be moving with a velocity of 1,470ft. per second, the "work" accumulated in it will be represented by

$$\frac{165 \times 1470 \times 1470}{2 \times 32{\cdot}1908}$$

which is equal to 5,538,049 lbs. or 2,472 tons. That is to say, the force stored up in this shot is capable of lifting a weight of 2,472 tons 1ft. high.

Captain Noble.

Fig. 1, would cost at least $200 per ton or a total of $440,000 for the 10,000 feet; while those of Fig. 2, could be procured for $60, or a total of $132,000. Though the latter would cost for work,

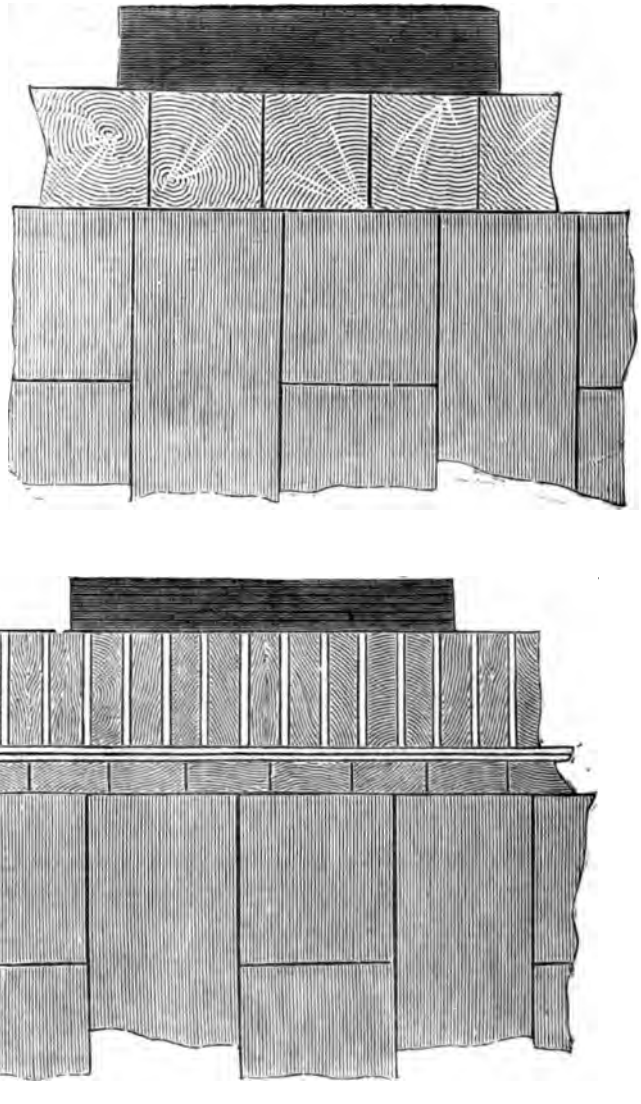


Fig. 1.

Fig. 2.

Scale ½-inch to foot

Stone Forts, with Iron Armor.

N.B.—The armor of Fig. 1 costs three times as much as Fig. 2, or for the same cost the latter could have twenty-eight inches of plating instead of eleven.

in putting the backing together, say $20,000 more than the former, it would still be little more than one-third of the cost of the thick-plate structure. The solid plates might possibly offer a better

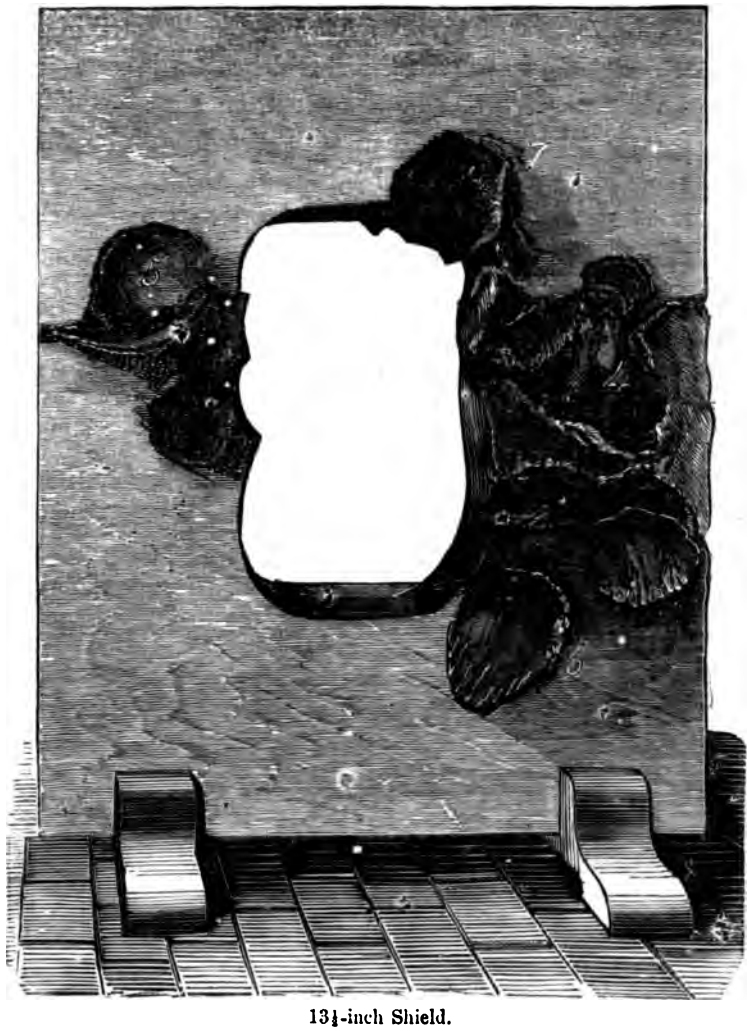
resistance to shot, though even that is doubtful, but the ship would not be so easily torn from its fastenings. The question of laminated *versus* solid plates, has not yet been fully and fairly tested. The views of engineers and scientific men generally are now undergoing a change on this subject, and many are of opinion that thick plating with its consequent treacherous fastenings may yet be superseded, both on land and sea, by super-imposed layers of iron supported by a backing of thin plates placed edgewise to the blow.

We have seen what became of the eleven-inch plate made by Bessemer, and the trial of the 13½-inch casemate shield has also been noticed, but a few more particulars relating to the latter experiment will show that those engineers who are looking for protection to a combination of light plates, are more likely to reach their object at a reasonable cost than those who pin their faith to mere thickness of iron. The following cut gives a fair idea of the 13½ inch shield in its present condition as shown in the Exhibition. It was made to protect a gun mounted in the aforesaid granite casemate. It is 8 × 6 feet, and has an embrasure, or porthole, (3 feet 6 inches in height, and 2 feet 4 inches wide) rounded off at the corners, and slightly bevelled on the inside to admit of training the gun.

The single shot fired at the Russian eleven-inch plate, struck with a force equal to 3,750 foot-tons, English (equal to 8,400,000 foot pounds), but the most trying shot fired at the 13½-inch shield, did not exert a power of more than 3,200 foot-tons, while several of the eight shots fired were under 2,000 foot-tons. The following table gives the particulars of the firing. Range 200 yards:—

No. of round	Guns.	Usual battering charge.	Charge employed.	Weight of Shot.	Work Foot-tons.
1	7 in.	22½ lbs.	18 lbs.	115 lbs. steel	1,411
2	8 "	30 "	22 "	150 "	1,676
3	9 "	" "	" "	" "	"
4	9½ "	45 "	30½ "	222 "	2,662
5	10 "	50 "	36 "	285 "	3,154
6	10 "	" "	36 "	" "	"
7	9½ "	45 "	30½ "	221 "	about 3,000
8	9½ "	" "	30½ "	217 lbs. cast-iron	2,500

The work in No. 8 round, (cast-iron shot) was expended chiefly on the shot itself, while rounds 1, 2, and 3, served only to make up the total of metal fired, without doing much damage to the shield. The actual work done, therefore, was the



13½-inch Shield.

result of rounds 4, 5, 6 and 7. Of these No. 6 struck on the lower right hand corner, the strongest part of the shield; and No. 7 struck on the upper corner, and glanced into the embrasure expending its work on the gun and carriage inside. There

remain then only two rounds (4 and 5) which in reality did the damage shown in the woodcut. One cracked the right hand side, and the other the left, clean through, so that the shield is now held together by dowels of 3 inches in diameter. There can be little doubt that a single shot like that fired at the Russian plate with its stored-up work of 3,700 foot-tons, would (striking where rounds 4 or 5 struck) have sent the shield broken in two into the casemate. What then would be the effect, on such a shield, of a steel shot from the 15-inch Rodman with 100 lbs. of powder, and a *vis viva* of over 7,000 foot-tons ?

We have dwelt on these experiments longer than we originally intended, still, if these facts and observations be instrumental in preventing the expenditure of the public money on expensive and unreliable works, we shall not regret that so much time and space have been occupied in discussing them.

CHAPTER IX.

IRON-CLAD SHIPS.

THE illustrations and models of iron-clad ships of war in the Paris Exhibition are, as a whole, more varied, comprehensive, and interesting than any other class of war material exhibited. Nevertheless, a cursory glance will suffice to show that the European iron-clad is still an embryotic production, indefinite as to its mission, or the means by which that mission is to be accomplished. Whether it is to be a ram, crushing its antagonist by its own momentum, or a huge gun-carriage, depending on one or two large cannon for its offensive qualities, has not yet been determined. A great number of the models exhibited are intended to combine both of these qualities. In others, again, such as the French "Gloire," and the British "Warrior," the conventional ship-of-war type, with its broadside of many guns, is still adhered to. The Monitor—pure and simple—does not seem to be in favor with European naval constructors, though the turret principle, especially in projects, is well represented. We shall endeavour to notice the respective exhibits of each nation, more particularly such features in them as tend to illustrate the progress making in iron-clad construction in Europe, and the direction in which the science of naval warfare is tending.

Before, however, adverting to the question in the shape in which it presents itself in the Exhibition, it will be well (and may lead to a better understanding of the subject) to notice briefly, the several stages through which the construction of European iron-clad ships have passed. British writers generally, ascribe the suggestion of iron armor to citizens of the United States,* though

* It is said the Dunderberg was designed in 1853.

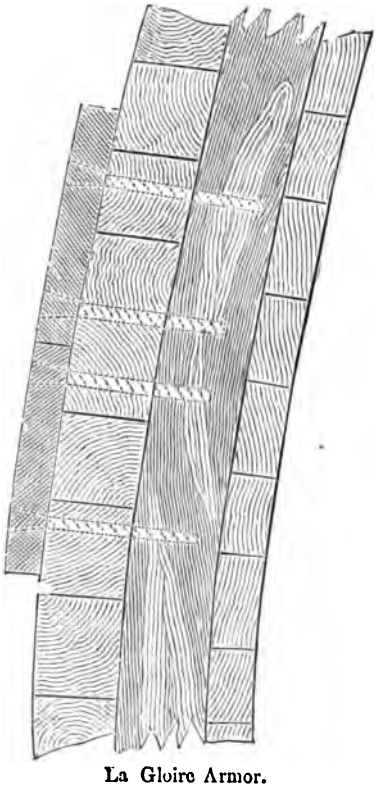
necessity only forced it into practical use both in Europe and America. The *Scientific Review*, of London, in an article on armor says:—

"It was the Crimean war that gave the first impulse to a more efficacious armament of the infantry, the fire-arms of which disagreed in too great a measure with the present exigencies of range and accuracy. It was the gigantic scale of the Russian defences that suggested the first practical essay of heavy rifled artillery, which step, coupled with the loss smooth-bore artillery had suffered through the extensive introduction of superior fire-arms, rapidly led the way to the application of rifling to field, siege, and lastly even to naval guns. And again, it was pending this war that the attempt was made of defying the murderous power of horizontal shell-firing, by resorting to the scheme, apparently impracticable, of applying wrought iron slabs of armor to the sides of floating structures called batteries. The idea was not novel. Mr. Stevens, of the United States, first conceived the plan of covering wooden batteries, somewhat similar to D'Arçon's, with inclined plates of sufficient thickness to resist both solid shot and shell. Ten years later Paixhan, after he had invented his destructive hollow shot guns, proposed to neutralise their formidable character by plating batteries with thick wrought-iron armor; thus acting very much like, though in the reverse way to, the celebrated Vauban, who after having fortified a considerable number of towns, invented the ricochet fire of the siege batteries, when called upon to overcome the resistance offered by his own fortifications and defensive combinations."

The chief object of iron armor for ships of war was to keep out shot by breaking them up on impact. The destruction of the Turkish fleet by a couple of broadsides in the roadstead of Sinope, taken in connection with the impunity with which the French batteries attacked the Kinburn Forts, proved the value of iron plating so far as to induce the Goverments of France and England to accept the new method of naval construction. The French, retaining the idea of inclined sides like those of the "Dundernoop," plated a wooden ship of the ordinary frigate type, with iron plates, of 4½ inches in thickness. These plates are comparatively easily made, put on, or removed, and are attached to the ship's side by a plentiful supply of wood-screws, screwed into the timber backing. The "Gloire," in short, has a timber scantling, similar to that of any line-of-battle ship, covered by a 4¾-inch

plate. Of this armor the annexed woodcut is a vertical section, without details, and with the exception of an increase of from 1½ in. to 3 inches to the thickness of the plate, French armor is the same still. This increased thickness of plate, however, has been obtained by sacrificing the protection of a large portion of the ship's surface, a feature of European iron-clads that will demand some attention farther on.

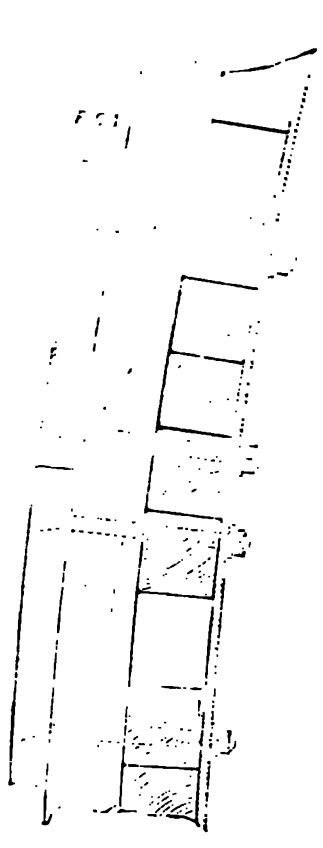
Scale ¼ in. to foot.



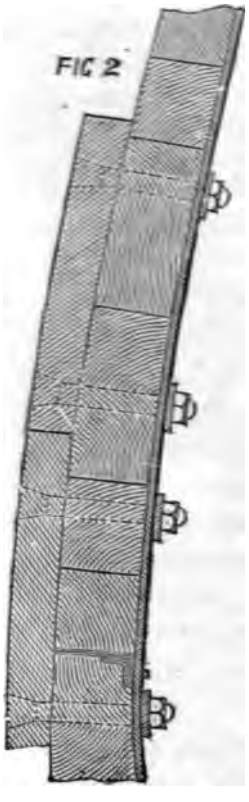
La Gloire Armor.

England followed pretty closely the lead of France in regard to the thickness of the plate and backing, but her "Warrior," was an iron, not a wooden ship. Figure 1 of the following sketch is a vertical section of the "Warrior Target," without details of fastenings, &c. Though this target gave very satisfactory results, when attacked by the 68-pounder smooth-bore and the 110-pounder Armstrong gun, it was evident that improved ordnance was coming into general use that would soon render the "Warrior" armor useless. Notwithstanding this acknowledged inefficiency of the Warrior type, the next step taken by the British Admiralty was a retrograde step. In the three largest ships of the navy (the largest and most costly ships of war ever built) the timber backing of 18 inches was reduced to 9 inches, and the iron plate increased from 4½ in. to 5½ inches in thickness, thus reducing the entire thickness of ship's side to 15·125 inches. A target representing the armor of these three ships (the "Minotaur," "Agincourt," and "Northumberland") of which Figure 2 is a sketch, was tried at Shoeburyness, and such shot as failed to penetrate the "Warrior target," "swept clean through that of the "Minotaur," carrying plate, backing, skin, frame and all before it."

[illegible] little room to doubt that a shot from the 15-inch Rodman, [illegible] represented in the woodcut p. 138) with a 60lb. charge



Warrior Armor.



Minotaur Armor.

would pass in at one side, and out at the other of such ships as the "Minotaur" and her consorts. The severe strictures of the London press, doubtless helped to prevent the construction of any more ships of this class. The *Times*, referring to the trial of the Minotaur target, said: "It almost crumpled up under fire." But though these ships were not commenced when this trial took place, the leading journal, years afterwards, lamented, that "the very reverse of what the experiments pointed out had been persisted in." "They built these ships," says the *Saturday Review*, "not in accordance with, but in the teeth of the experiments." The

Mechanics' Magazine said, "So far as effective service is concerned, they might as well be classed with the three-deckers now rotting at their anchors, at Portsmouth and Sheerness, for the ordnance with which the great maritime powers are arming their ships, can destroy our Minotaurs as easily as the Russian guns destroyed the Turkish fleet at Sinope." Nor were there wanting other and more authoritative warnings, given in ample time to prevent so great a blunder. The Iron-plate Committee, under whose auspices these experiments took place reported, that, "the reduction of the timber backing is a source of weakness, for which the extra thickness of the armor-plate is not sufficient compensation," for the Minotaur target was in a far worse condition after receiving only 740 lbs. weight of shot, than the Warrior target after receiving 3,980lbs., at similar velocities."

Thus, by following this retrograde step of the British naval constructors, we have seen that in naval armor, as in armor for land works, mere thickness of iron plating will not give effective protection, and we come back to the point from which we started, proposing the question, Where then is protection to be looked for? A glance at the next stage will probably furnish a tolerably satisfactory answer. We have seen the French settle down satisfied with the essentially unscientific method of screwing plates of various thicknesses to the sides of wooden vessels. With the exception of a few rams and floating batteries for coast defence, these characteristics describe the French Navy still. Some naval powers such as Spain, Italy, and Austria have, to a considerable extent, followed the French, while Prussia, Denmark, Holland and Turkey, seem to follow in the wake of England. Hence, the question of an efficient armor for ships of war was a wide question interesting to, and affecting many nations.

"A problem of this nature," says the London *Telegraph*, "could not fail, as a general rule, to absorb the attention of engineers, and promote emulation amongst them; but in the present case it had the exceptional qualifications of exciting an intense feeling of interest in the public at large, of holding out unusual promises, and, lastly, of opening a great field to ambition. As was to be expected in a case like this, men of all classes came forward, and, of course, all sorts of ideas were brought to the surface, some feasible, others absurd. Of the former, many were charac-

terised by an endeavour to attain resistance at the expense of the backing, the plate alone being looked upon as the element of impenetrability. Many of our most eminent engineers adhered to this plan, forgetting, strangely enough, the mechanical principles which cause the blacksmith to give the anvil an elastic foundation of wood in solid blocks—which enable the cobbler to hammer leather on his knees, by using a thick and heavy stone as a cushion—and permit railroads successfully to bear enormous weights.

Other plans, on the contrary, laid great stress on the part played by the backing; in fact, they took a line diametrically opposite to that followed by the former, their originators having evidently understood the lesson conveyed by the comparative superiority of the "Warrior" with regard to a system based on the use of thicker plates and thinner backing. They may not have seen what constitutcd the secret of impenetrability, but it was apparent to them that, by improving the rigidity, and at the same time the elasticity of the backing, they would increase the resistance to compression, and proportionately diminish the plate's tendency to buckle and give way before the shot. One would have thought these principles plausible enough to merit fair consideration, or novel enough to excite official curiosity. Such, however, was not the case in any way; the Admiralty being either unable to appreciate the scientific features, or determined never to depart from their own favourite ideas, right or wrong. Be this as it may, we find that amongst the persons who sided with the backing a certain Mr. Chalmers distinguished himself especially for his perseverence in bringing the question into notice, and at the same time for his faith in the practicability of his invention."

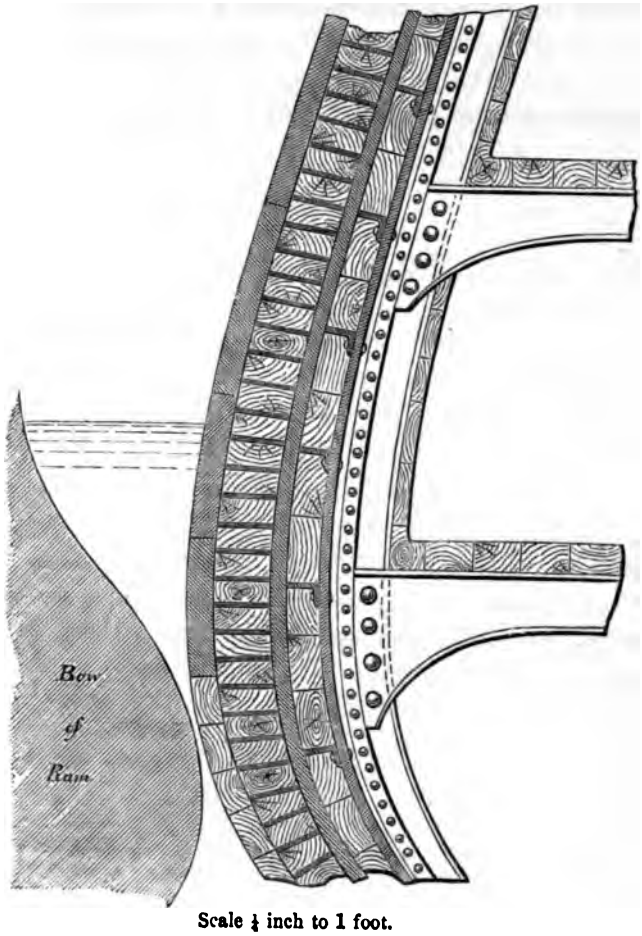
This invention, and the target in which it was tried at Shoeburyness,* has perhaps attracted more attention in Europe, than

* A further trial of this invention was made this year at Vincennes, some idea of which may be gleaned from the following extracts from the *Pall Mall Gazette*, and the *Standard*. The former says:—

"Some experiments as to the strength of targets were, we hear, made yesterday at Vincennes, when the 9-inch 12-ton Armstrong gun failed to penetrate a 5½ inch plate of soft iron backed on the Chalmers system. Half-a-dozen rounds were fired at twenty-five yards distance, and at the close of the experiments it was found that three of the shot were lying in front of the target, and three sticking in the backing. The full service charge of 43lbs. of powder was employed, and the steel shot had the ogival head recommended by Major Palliser. It is only about ten days ago that the 7-inch Armstrong with a 15 lbs. charge sent the Palliser shot through plates seven inches thick at Shoeburyness. The plates were without backing, and were composed of two 2-inch layers of wrought-iron enclosing a 3-inch layer of steel."

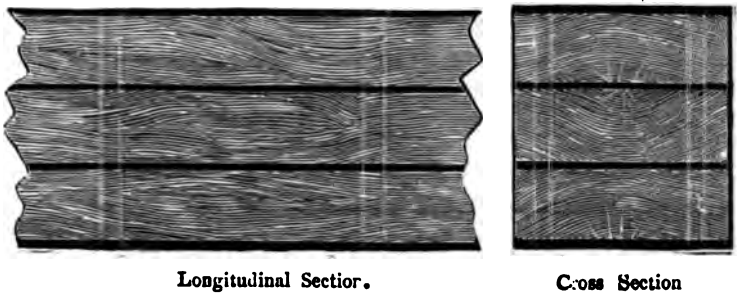
"These experiments seem to deserve attentive consideration. Strict comparison

The Chalmers System of Armor.—Fig. 1.



Scale ½ inch to 1 foot.

Improved Compound Backing.—Fig. 2.



Longitudinal Section.

Cross Section

Scale, 1 inch to 1 foot.

any other contrivance for keeping shot and shell out of ships of war. It is illustrated in the Exhibition by models and drawings. Our woodcut will illustrate the principles embodied in this invention. Fig 1 represents this system as tried in the Chalmers target, which had a $3\frac{3}{4}$-in. armor-plate, a compound backing, a second plate, and a cushion with stringers (running at right angles to the ship's frames) between the second plate and skin, the stringers being rivetted to the latter. The inventor suggests that his system of compound backing would materially aid a ship in resisting the blow of a ram, for the backing could, as represented, be carried below the armor-plates, and, by thus presenting a series of well-supported ribs of iron on edge, it would distribute the blow of a ram over a much greater surface.

Fig. 2 represents the compound backing on a larger scale. The weight of materials represented in the woodcut, Fig. 1, if for ships of the "Warrior" or "Minotaur" class, the iron of the three systems would be distributed in about the following proportions:—Chalmers' plan, 46 per cent. in the structure, and 54 in the armor-plate; "Warrior" plan, 32 per cent. in the structure, and 68 in the armor-plate; "Minotaur" plan, 26 per cent. in the structure, and 74 in the armor-plate.

As the trial of the Chalmers target has influenced the construc-

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with those recently made against combined steel-and-iron plates at Shoeburyness is hardly possible, because the plates there were unsupported, and the effects of the Palliser missiles upon them was more of a simple punching nature. Still when we regard the fact that in our experiments a 7-inch gun was used against 7-inch plates, and just penetrated, when propelled with 15lb. of powder, we must accord some very considerable value to Mr. Chalmers's backing when, with its assistance, a $5\frac{1}{2}$-inch plate can be made to keep out the larger and heavier shot from a 9-inch gun. We know, that in these last Vincennes trials, the effect of two or three of the stringers in the backing brought into resisting action simultaneously by the impact of the missile prevented penetration, even with full charge. This would seem to indicate that the number of iron laminæ in the backing might be increased and the thickness of the wood planking diminished, or, in other words, that the more frequent alternations of wood and iron planking would be beneficial to resistance offered by the Chalmers target. These particulars would also seem to extend the proofs of the value of Mr. Chalmers's system."—*Standard.*

tion of British iron-clads, and consequently those of other nations who follow her lead, it will be both useful and interesting to consider for a moment this experiment and its results. The target was furnished by the inventor free of cost, on condition, that if it resisted better than the "Warrior" and other targets previously tested, he should be paid his expenses, not to exceed £1,650 ($8,250). The practical results of the trial, in a word, were non-penetration by the guns and projectiles hitherto used; the absence of the usual buckling of the armor-plates; and a practical security of the fastenings by the use of a shallow thread in the armor-plate bolts. One of the targets which preceded this by only a few months, had 21 out of 23 bolts on one side of the porthole broken by nine rounds, whilst the Chalmers target had no bolt broken up to the 24th round, when one snapped under a salvo of five shots, from two 68-pounder and three 110-pounder guns. The *Times* said it was "the only target that had fulfilled all the requirements of strength, so needed and so long sought for;" and the *Daily Telegraph* stated that, "it was proved—proved beyond a doubt by the issue of the Chalmers target that the resisting power of armor was far more dependent on the nature of the backing, than on the thickness of the plate." Before these opinions appeared, however, the Secretary of the Admiralty stated in Parliament referring to this trial, that "if this experiment be favorably reported on, it will lead to important alterations in the construction of our iron-plated ships." The Iron-plate Committee, in summing up their report,* said "No other target designed for naval purposes has

* The following, from the *Standard,* are extracts from the Report of the Iron-plate Committee:—"The target was fired at with steel and cast-iron projectiles from the following guns:—68-pounder smooth-bore, with cast-iron shot and shell, 16lbs. charge; 110-pounder Armstrong, with cast-iron shot and shell, and 12lb. and 14lb. charges; 300-pounder Armstrong, with cast-iron spherical shot and 50lb. charge, and lastly, with the steel solid shot of 301 lbs. from the 300-pounder Armstrong with 45lbs. charge. . . . . The experiment proved that this system of backing affords great support to the armor-plates, and prevents their distortion from buckling. It is also of considerable advantage in adding strength and resisting power to the structure. . . . . No other target designed for naval purposes has resisted a similar weight of shot with so little injury. . . . . The backing proved much more substantial than the backing of wood without the interposition of the iron plates, which seem to prevent

resisted a similar weight of shot with so little injury," and the Lords of the Admiralty wrote to the inventor, saying that the suitability of your plan to wooden as well as to iron ships, has been, and still is, under consideration." Now it will be necessary to a due appreciation of the subject, to see whither this "consideration" tended. The *Scientific Review*, says: "The Chalmers target showed the value of stiffness and elasticity, and led the way, first to the Bellerophon armor, and then to the Lord Warden," and Mr. Chalmers himself contends, "that the result of this consideration has been the adoption and construction of two new classes of armored frigates, the Bellerophon class iron ships, and the Lord Warden class wooden ships." This is not only the opinion of the inventor and the press, but Sir John Hay the Chairman of the Iron-plate Committee stated in Parliament, "that one of the most essential and valuable principles of the Chalmers target had been embodied in the "Bellerophon." That was his opinion, and also that of the Iron-plate Committee."

Having thus traced the history of British iron-clad armor to the introduction of horizontal plates, or stringers, between the timbers of the backing, it is desirable to see if the principle of a compound backing has been fairly carried out.

Our engraving of the armor of the "Bellerophon" will show that the adoption of Mr. Chalmers's plan has not been so complete as the above opinions would lead us to suppose. The fact that this system was devised at the same time that Mr. Chalmers's plan was under consideration, and by the very parties who were con-

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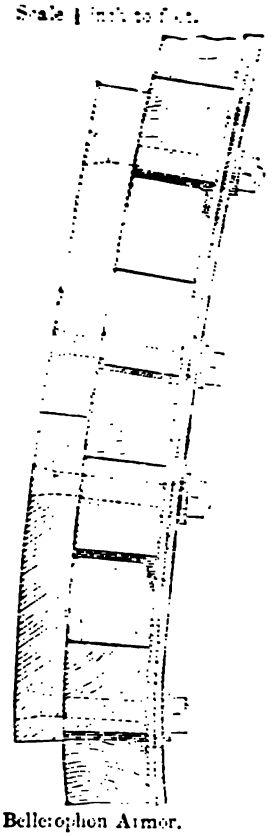
the crushing of the wood, and the spreading of the fracture to the contiguous portions of the backing. It would also probably tend to prevent ignition from the explosion of shell, and evidently affords great support to the armor-plate, as was shown by the furrows on the rear of the plates.

"The Chalmers target, though of much smaller area than the Lord Warden target, suffered much less from the blow of the 10·5 steel projectile with 45lb. charge. The area of destruction in the Lord Warden target being 8 feet by 4 feet, whereas the area of destruction in the Chalmers was 2 feet by 1½ feet."

Area injured in the Lord Warden target ... 32 feet
Ditto ditto Chalmers' ,, ... 3 feet
Weight of the Lord Warden target, per foot 482.9lb.
Ditto Chalmers' ,, ... 371.5lb.

sidering it, leaves little doubt as to whence the new features were derived, but it is open to question whether much real advantage has been derived from the *partial* adoption of a plan, that as a *whole*, seems founded on sound principles. An able writer in the *Daily Telegraph* on this point observes,



Bellerophon Armor.

"The principal features of the Chalmers plan were evidently embodied in this. If the designers of the "Bellerophon" had mastered the real secret of the resistance attained in the Chalmers target they might easily have improved on the latter without going beyond the intended weight; but then the similarity between the original and the derived targets, would necessarily have been more marked, so, to avoid this, some slight alterations were introduced, to the prejudice, rather than to the advantage of defensive qualities."

The weakness of the armor of the "Bellerophon" (said to be the strongest British iron-clad afloat) is strikingly illustrated by one of the plates of the Bellerophon target, shown in the Exhibition, and which we will refer to more fully when we come to speak of the ship models exhibited in the Marine Section. Suffice it at present to say, that this six-inch plate has been completely riddled by a seven-inch 6½-ton gun, with 115 lbs. shot and 22lbs. charges. The plate of course is exhibited to show the penetrating power of the gun and projectiles.

Before closing this cursory sketch of iron armor, and taking up the question in detail, as illustrated in the English and other European models exhibited in Paris, we venture to suggest that the thin plates of iron interspersed in the backing, would, if placed *closer together* even, than in the Chalmers target, have given better results than when placed further apart, as in the Bellero-

phon, and in the target lately tested at Vincennes. Mr. Chalmers, as we have seen, proposes to continue his backing considerably below the water-line, with a view to enable ships of war to resist the blow of a ram, and suggests that thin laminated plates of iron on his backing, would offer an equal, if not a better, resistance to shot, than a similar weight of solid plating on a backing of timber. Laminated plates with this, or indeed any backing, have not, to our knowledge, been tested on the Continent; and in England the influence of the armor-plate manufacturers has been sufficient to prevent any trials likely to endanger their craft. The question, however, is one well worthy of attention, and if it be found that a judicious use of thin plates of iron, or steel, among the backing timbers of an iron-clad, will enable laminated plates, or even thinner solid plates to resist shot as well as the same weight of iron on a backing of timber, a great point will be gained, and a great saving effected in the construction of iron-clad ships.

"La Gloire," whatever may be her qualities as a ship of war, is in one sense, the *first* iron-clad in Europe, and therefore her failings, be they few or many, ought to be charitably considered. We have seen that she is a wooden frigate wholly covered, from her upper deck to six feet below her load-water line, with iron slabs $4\frac{3}{4}$-inches in thickness. It would have been a pleasing task, to have examined this, and other French ships minutely, but the lock and key of the glass case in which the models are exhibited forbid a close inspection, and sketching is prohibited. Nor are there sections shown, and dimensions given, as in the case of England and other countries. We have already given a sketch of the scantling and armor of "La Gloire," and no thickness of plate has been more tested in England, than $4\frac{1}{2}$-inches, the thickness adopted in the Warrior targets of which upwards of a dozen have been tested. However, a target constructed on the French system and called the "Small plate target," was tried at Shoeburyness, and the experiments against this target will give a tolerably fair idea of the resistance of ships of "La Gloire" and the "Flandre" class. One half of the target was covered with $4\frac{3}{4}$-inch plates to resemble the "Gloire" armor, and the other half with 6-inch plates (5″·9) which represents the armor of a large proportion of the French Navy. See the following table:—

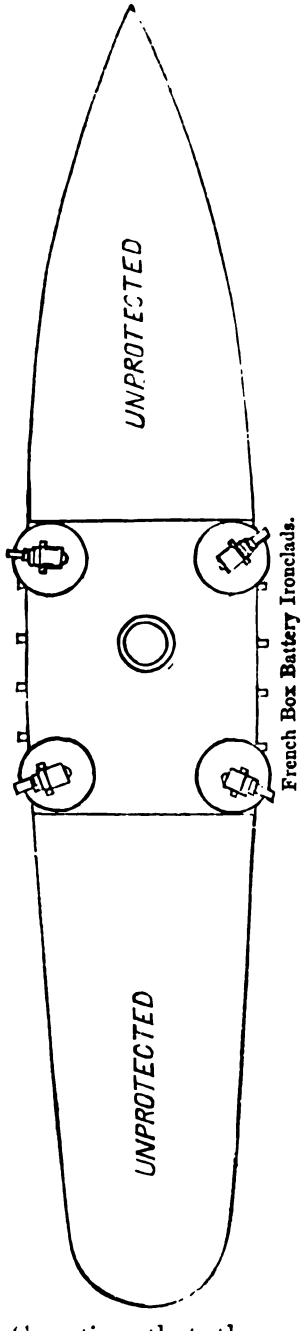
Table of rounds fired at the "Small-plate target," at Shoeburyness, one half of which consisting of 4¾-inch plates, represented the French iron-clad La Gloire, and the other half of 6-inch plates represented the Solferino, Magenta, &c. The powder used was L. G. rifle powder, and the range was 200 yards.

Round.	Plate.	Gun.	Charge.	Projectile.		Striking Velocity.	Work in foot-tons.	Remarks.
				Nature.	Wght.			
	inch.		lbs.		lbs.			
No. 1	6	68 pdr. smooth bore	16	Spherical cast-iron	66	1382	878	Indent about 2·2 inches.
„ 2	4¾	Ditto	„	„ steel	73	1371	962	„ 3.9 inches, cracked round bottom.
„ 3	6	7-in. B. L. 81 cwt.	12	Cylindrical steel	110	1090	914	„ 2.8 inches, plate cracked at back.
„ 4	4¾	Ditto	„	Ditto	„	„	„	Penetrated and stuck in plate.
„ 5	„	9-in. 12 ton M.L.	30	„ chilled	259	1222	2682	Target completely penetrated, massive knee driven 8 feet to rear, shot broke up.
„ 6	6	Ditto	25	Spherical steel	113	1452	1659	Indent in target 10 inches.
„ 7	„	Ditto	30	Cy indrical steel	222	1310	2642	Target completely penetrated, rear supports (16 in. sq.) smashed, shot struck "Scott Russell target" behind.
„ 8	4¾	Ditto	44	„ cast-iron	258	1375	3384	Target penetrated, massive knee driven 16 feet to the rear. Shot broke up.
„ 9	6	10.5 in. M.L.	35	„ steel	297	1105	2514	Target completely penetrated.
„ 10	4¾	Ditto	22½	Spherical steel	166	1200	1657	Through target which was, however, badly shaken by previous rounds.

A few more rounds were fired, with like results. The most interesting round in the above table is doubtless the 10th. Here a spherical steel shot of 166 lbs. weight, propelled by 22½ lbs. of powder, attains a striking velocity at 200 yards of 1,290 feet per second, and carries with it 1,657 foot-tons of work. It passes clean through the target which, though "badly shaken by previous rounds," was struck on a comparatively sound spot. This round indicates what our eleven-inch smooth-bore (not to speak of larger calibres) can do against French "Gloires," British "Royal Oaks," and similarly plated wooden frigates. Considerably less than 2,000 foot-tons, lodged in a round steel shot will suffice to crush in the sides of these ships, and a shot from the eleven-inch Dahlgren with 30lbs. of powder would exert a power of about 2,500 foot-tons at 500 yards. Referring to these, and similar experiments, the *Times*, last year, said:—

"If any certain conclusion can be deduced from the long series of experiments which have been made on this ground, it is that armor-plating as applied to ships is really as vulnerable now to our present ordnance and projectiles as the wooden frigates ten years ago were liable to be knocked to splinters by the old 32-pounders and 68's. There is no blinking or concealing this plain fact. There have been wonderful targets tried at Shoebury, and the best of all was that of Mr. Chalmers; but their victory over the guns has ever been, as we have said, but of the most temporary duration. The limit of weight in armor-plating which a sea-going frigate can safely carry has been fully reached, if, indeed, it has not been overpassed."

These trials, and the comments they have given rise to, have sorely tried the patience and taxed the ingenuity of European naval constructors. But instead of adopting the course pursued in our navy, of showing as little as possible above water and effectively protecting all that is exposed, they have imitated the Irishman, who to lengthen his blanket cut a piece off the bottom and sewed it to the top. They (especially M. Dupuy de Lôme, and Mr. Reed) have deprived one portion of their ships of all protection whatever, in order to give another part such weight of plating as may for the present moment seem sufficient. The only French ship shown in section—the "Marengo," one of the very latest designed and not yet completed—will illustrate this. Her hull is the same as that of any wooden frigate, save that the



bow, for twenty feet or so, is of solid timber and covered by a brass cleaver, the ship being intended to act as a ram. Though, as regards her hull, the "Marengo" is a wooden ship, she is much stronger, having iron beams and knees. Her protection consists of 7½-inch plating, from three or four feet above the water-line to about seven feet below, the belt of armor tapering off to about three inches at the lower edge. In midships, she has a battery sixty-five feet in length, protected on the sides by plates, six inches thick. This battery is protected fore and aft by a bulk-head of similar scantling to the ship's side, and plated with 4½-inch plates, which reach from the upper deck to several feet below the water-line. Thus the protected battery is a square box amidships as shown in the woodcut.

This battery contains eight 7½-inch guns, four on each side, and when we consider that the funnel passes through it there cannot be much space for working these 8-ton guns. A fixed turret protects a turn-table mounting a 9½-inch, 13¾-ton gun, on each corner of the battery, the gun itself, however, being above the turret, is exposed. The total length of the ship is 300 feet, consequently a length of 235 feet on each side, or an area of about 4,500 superficial feet of the side of this new ironclad,(?) has no more protection than any wooden frigate of the old type. Granting that the small box-battery amidships is invulnerable,

the unprotected parts, with the masts and rigging, would be easily set on fire, the smoke and heat of which would drive the men away from the unprotected turret-guns, and interfere with the loading and training of the guns inside of the battery, whilst the demoralization of the crew, arising from the knowledge that both ends of the ship were on fire, would be as difficult to allay as the fire itself, and fully as disastrous as the enemy's shot.

In the same case with the "Gloire" model, there is a model of an iron-plated frigate of the "Flandre" type, of 900 horse power, with a four-bladed screw. This vessel is short and broad, but the lines are well formed. There is also a model of the iron-plated frigate, "Solferino," with a ram-bow, and six bladed screw. This vessel, like the "Marengo," is only plated amidships, and along a belt at the water-line. The ram is triangular in its vertical profile, but it merges well into the well-formed lines of the ship.

There are also exposed in this case models of the floating-battery "Embuscade," of 120 horse-power, a flat-floored, broad, and short vessel, with guns all round, and driven by four-bladed twin-screws; and a model of the floating-battery "Arrogante," also of 120 horse-power, similar to the "Embuscade," but reduced in height at the ends, so as to form the greater part of the vessel into a central fort, carrying nine guns on each side and three guns at each end. There is also a model of the coast defence-ship "Bélier" of 530 horse-power, in which the sides converge and are netted into the deck, and of which the armament consists of two guns set in a turret placed well forward to balance the weight of the machinery.

"The whole of these models," says *Engineering*, "are exceedingly well executed, and the forms of the vessels are good for moderate rates of speed. But there is nothing in any of the arrangements that is worthy of imitation, or that shows that the advisers of the French Government have attained any just appreciation of the powers and qualities indispensable to the success of modern ships of war." "The most remarkable of these models," says the same journal, "is a submarine boat driven by a six-bladed screw at the stern. Motion is given to the screw by engines worked by compressed air, and an air-boiler or reservoir is placed near the bow to balance the weight of the engine, while another similar reservoir is placed

upon each side of the vessel further aft. Midway down in the prow is a long tubular bowsprit or spur, carrying a torpedo at its extremity. The deck and sides are of course merged into one by carrying the sides in a curved form over the upper horizontal surface, usually constituting the deck, and into this rounded top or deck, a small boat is so indented that when in its place it forms a portion of the main vessel, but yet when liberated it is of the proper configuration to be suitable for a boat. This boat is also covered over, water-tight, and is entered through a hole in the bottom from the main vessel, a suitable manhole, closed by proper contrivances, being made in the socket which receives the boat on the deck of the main vessel to enable a person to pass from the one to the other. At the end of a small vertical shaft rotated by hand and projecting above the deck of the main vessel, a screw is set for the purpose of raising or sinking the vessel in the water. This model was executed at the port of Rochefort, and the arrangements exhibit ingenuity. But in many points the plan is inferior to that of D. Bushnell, projected in America nearly a hundred years ago."

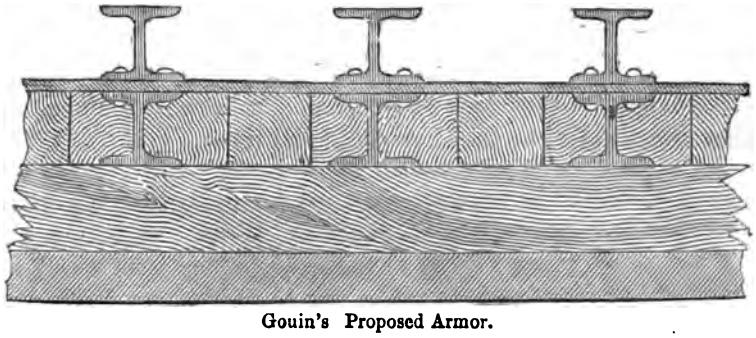
The exhibits of the private firms of France are not extensive. The Marseilles company "Des Forges et Chantiers de la Méditerranée," along with several models of marine engines, show a model of the Spanish frigate "Numancia," which took part in the bombardment of Valparaiso and Callao. The "Numancia," is an iron ship, completely armored with 5-inch plating on a 16-inch backing of timber, consisting of a horizontal layer of 4-inch planking, and verticial timbers 12 inches in thickness. On the whole the "Numancia" seems to be a more powerful man-of-war than any of the ships (as represented by the models), of the French Navy. Though she is 70 feet shorter than the "Achilles"—the most powerful iron-clad possessed by England*—she carries a greater weight of armor per square foot (her armor-plates weigh 1,500 tons), and is, at least her equal in resistance to shot, while in consequence of the difference in length, she is a much handier ship, and her cruise to the Western Coast of South America bears ample testimony to her sea-going qualities. This ship cost £1,579,000, without her armament. The "Numancia" was struck at Callao by a 300-pounder shot, which penetrated the iron plate

* "I feel bound to award the first place as a vessel of war, as a sailing ship, and as a steamer to the "Achilles."—*Admiral Yelverton.*

and stuck in the backing. This shot, doubtless, struck obliquely, or was fired with a light charge, for there is little doubt that round No. 7 in the foregoing table, striking direct, would penetrate the side of the "Numancia," as also would our 15-inch shot fired with 60lbs. charge at 500 yards.

Near by, stands the only iron-clad model (in section) shown by a French firm. This is exhibited by E. Gouin & Co., of Paris, and, as yet, is only a project. It is a half section of an iron frigate with a double cellular bottom. Its chief peculiarity is its double H-framing, of which we give an illustration. The object

Scale ½ inch to foot.



Gouin's Proposed Armor.

aimed at seems to be "a method of fastening with fewer through-bolts than are generally used." But the system involves constructive difficulties of no ordinary kind, such for instance as the fitting of the timbers *a*, *a*, and the key-plank *b*, between the rivetted H frames. The vertical frames notwithstanding their great depth and weight, being separated from the armor-plate by a cushion of timber planking, do not, as in the Chalmers system, support the plate, or offer any resistance to the shot till the plate and backing are first penetrated.

In the same class (66) Denmark shows a model of the stem or bow of a floating battery, built to carry two 300-pounder Armstrongs in one cupola. The length of this craft is 208 feet, breadth over all, 40 feet, and depth of hold 17 feet; her draught of water being 12 feet. Her armor consists of a 4½-inch plate resting on a 12-inch timber backing, with horizontal stringers resembling the compound-backing of the Chalmers target, or that adopted in the English frigate "Bellerophon."

Further on, in the same circle, we come to a model of the Austrian frigate "Ferdinand Max," which ran down the "Re d'Italia," at Lissa. This is a wooden ship of "La Gloire," type, plated all round with $4\frac{3}{4}$-inch iron. She has 800 horse-power engines, and a deplacement of only 5,100 tons. Her armament consists of sixteen 160-pounders, and her swan-neck shaped cutwater is armed with a cleaver, that makes her the powerful ram which, at Lissa, she proved herself to be.

Since armored ships have come into fashion, one would expect that more attention than heretofore would be given to the question of subaqueous artillery. Though the bottom of an iron ship is now, and is likely ever to be, a weak point inviting attack, there are very few contrivances for this mode of warfare on view at the Paris Exhibition. Some torpedoes are shown by the Austrian Government which are chiefly intended for harbor defence. The following from the *Standard* has reference to these:—

"The torpedoes, of which a specimen is exhibited, are flattened cylinders, about four feet high and the like in diameter. From the bottom a chain descends, and passes through a clip at the end of a long steel wire 7-strand rope, attached to a heavy bell-shaped or rather hemispherical iron anchor. The chain can be passed through the clip in one direction, but cannot be pulled back; by this means the crews of the boats laying the torpedoes can pull the chain through the clip until the torpedo is sufficiently submerged—say to 12 feet below the surface; the end of the chain is then let go into the water, and the clip holds it firmly in position. In this way each machine is successively moored. From the upper part of the torpedo there project at suitable intervals numerous large broad-headed iron studs, the long shafts of which penetrate into the top portion of the torpedo, and when any one of these studs is struck its shaft is driven against one of the teeth of an internal ratchet wheel, which partially turns and brings internal projections in contact with the electrical wires, when the exploding spark fires a composition somewhat similar to that of our Abel fuzes, but probably more sensitive. A special apparatus is necessary to permit the electrical currents to pass from all the torpedoes, and the same apparatus will test the insulation of each, as well as detect those which have exploded. The action of the contact made by the mechanical stud of the torpedo is that the current immediately passes to earth; when therefore a torpedo has been exploded its cable carries off to the water a considerable quantity

of electricity, and it is requisite to sever its wire to avoid this loss. To detect it a bridge of copper is brought over from the connecting wire of battery to the apparatus to which all the wires of the torpedoes (Siemens's laminated copper small cables) are attached, and a short circuit is thus made with a needle-dial. As the circuits of the unexploded torpedoes are interrupted, no action takes place by connection with them; but when the one is touched which is conveying electricity to the earth, or rather to the sea, the needle flies rapidly over and indicates the wire which should be cut adrift. The charge in these torpedoes is 168 kilos., or about 3 cwt. of sporting powder; the reduction is made in consideration of the immediate proximity of the explosion to the vessel sought to be destroyed."

With the exception of a crude model in the English section and another equally crude, but more pretentious design in the French, there are no plans exhibited for firing submarine projectiles. We have been led to these reflections by the examination of the French model, M. Fourcy's "Batterie sous marin." His plan briefly consists in placing the muzzle of the gun into a stuffing-box, and forcing it outwards through an opening protected by a valve in the ship's side; when the gun recoils the valve closes and the operation is repeated. A submarine projectile possessing great novelty was lately discussed in the *Engineer* and though the invention is not in the Exhibition it is none the less interesting. From the article in question, we extract the following:—

"It is somewhat extraordinary that, amongst the number of schemes of subaqueous explosion for warlike purposes, there is hardly any record beyond what we are now to make of subaqueous projectiles.* The ingenuity of engineers seemed to restrict itself to the proposition of establishing a mine at some fixed point in a channel, and then allowing it to stay at rest until an enemy's vessel might happen to pass over it, when by some sufficient device the mine should explode. Yet it would seem more desirable, if it could be effectuated, to launch a subaqueous projectile against a ship than to await the contingency of a ship passing over a stationary mine. The only sort of subaqueous projectile that comprises the conditions of prolonged flight—if flight be the appropriate word for such a medium as water—is the rocket; and granting the rocket's competence to take effect in a watery medium, then the use of this missile demonstrably presents

* Fulton designed a submarine battery about the begining of the century, the drawings and specifications of which were in existence not more than two years ago.

enormous advantages over every other projectile that could be launched against a ship. Long before 1862 it had been known that a rocket would propel itself through water, and therein generate considerable projectile force; but the specific novelty of the proposition laid before the British Admiralty in November, 1862, was that of regulating the subaqueous flight of an iron rocket by a system of flotation and pilotage, which, when explained, cannot fail to manifest its own advantages. An ordinary iron rocket being slung at a definite depth below the water-line by means of two metal stays from any convenient float, has pendent from it a rudder. Obviously the depth of the rocket below the water-line will be regulated and determined by the length of the stays, and the dimensions of the rudder would be regulated by experience. A rocket thus arranged when ignited, as might readily be accomplished by electricity, would obviously tend to go straightforward until the exhaustion of its propulsive force. Unlike an aërial projectile, which may incur deflection in any plane, a subaqueous rocket, arranged as here described, could only experience deflection laterally, vertical aberration being prevented by the float and regulating stays. A rocket, however used, is endowed with certain advantages an ordnance projectile has not. To the dimensions of a rocket, there are hardly any imaginable limits; then, again, its first moment of flight being attended with no initial shock, many explosive bodies may, if desired, be used for charging rocket heads, though wholly incapable of employment by ordinary artillery. To fire a slung rocket, like the one just described, from a ship against a ship would not be very difficult, but the special service indicated to the War-office and Admiralty, as falling within the province of these slung rockets was that of establishing a perpetual protection at harbour mouths. It is easy to understand that an entire coast-line might be converted into a battery of such slung rockets at convenient distances apart, and converging, if desired, towards one or more points whereat a hostile fleet might be expected to pass. Equally easy is it to understand that any number of these slung rockets might be kept in perpetual communication with an electric reserve, whereby they might be discharged when necessary."

Before passing to the British Naval Department on the banks of the Seine, we shall examine the exhibits of the several armor-plate makers which are scattered about the parks, and main building. Very fair specimens of plates, of from 4½ inches to 6 inches in thickness, are exhibited by Russia, Austria, Italy and other Continental countries, but the chief displays of this branch of war material are those of France and England. The former are chiefly of small dimensions, though some are nine inches thick. They

are exhibited by the makers, of whom Messrs. Petin and Gaudet are the most extensive producers. Some of the French plates exhibited have been fired at, but chiefly with cast-iron shot, and from guns of small calibre. They are only slightly indented with the rippling, saucer-shaped mark invariably produced by cast-iron round shot, and these, as well as two short plates nine inches in thickness, with six 9½-inch shot sticking in them, exhibited by the French Government, are shown to illustrate the quality of the plates and their powers of resistance. On the other hand the plate exhibited by the British Government is shown to illustrate the power of the Woolwich gun and projectiles, and is, as before stated, completely riddled. This plate is 20 feet long, four feet three inches wide and six inches thick. It was made at the Millwall Iron-works for the Bellerophon target, and it will be interesting to inquire into the circumstances and particulars of the firing that produced the terrible effects exhibited. For not only is the plate riddled, but the laminæ has been separated at the back for about six-inches, all around the hole, whereby an amount of metal, fully equal to the weight of the shot, has been converted into langridge and driven into, and sometimes through the backing. There is a something about all these armor-plate trials of the British Admiralty which is perplexing to the uninitiated, and these Bellerophon trials are no exception in this respect. When the Bellerophon target was first tested no shot was fired at it, but such as previous experiments had demonstrated would not penetrate. The reporters for the press on that occasion, noticed its "merciful treatment," the "unusual tenderness," of the trial. So the plate shown in the Exhibition was not on the Bellerophon target when it received the punishment referred to. But it was on a *much stronger* target, called the "Box-target." The "Bellerophon," has only 10 inches of wood-backing, but this had 18 inches with a double skin and the usual iron frame. The following table gives the particulars of eight rounds fired at this plate, the effects of which as exhibited in Paris show both the power of the gun and the vulnerability of the frigate whose armor the plate represents. The gun used was the 7-inch 6½-ton M.L. naval gun, and the charge in each round was 22lbs. of L.G. rifle powder. The range was 200 yards.

Round.	Projectile. Nature.	wt.	Striking velocity.	Work in foot-tons.	Remarks.
		lbs.	feet per sec.		
No. 1	Chilled Shot 13·62 in.	117	1338 ...	1432.....	Penetrated armor-plate and stuck in backing.
2	Ditto	116½	1331 ...	.....	Ditto to inner skin, which was slightly bulged.
3	Ditto 14·79 in	...	.....	.....	Ditto target completely, but skin was here only ⅛ in. thick.
4	Ditto, ogival head, 13·86in.	115½	1337 ...	.....	Complete penetration of target.
5	Ditto	116¼	1333 ...	.....	Ditto ,, ,,
6	Steel Shot ogival head 15·25 in.	115½	1360 ...	.....	Ditto, shot picked up inside whole.
7	Steel Shot, round head	115	1380 ...	1518.....	Struck on rib, or stringer, penetrated plate and backing, 18 inches, rib cracked, and forced slightly back.
8	Ditto	ditto	1371 ...	1499.....	Penetrated plate and lodged in backing, total indent about 14½ inches

Though only four of the above rounds *completely penetrated* the target, there can be little doubt that all the eight rounds would have gone clean through the original "Bellerophon target." Thus the resisting powers of the Bellerophon gave way before 1,500 foot-tons, an amount of work (making every allowance for the different form of projectile) within the capacity of our 11-inch smooth-bores at 200 yards, or the 15-inch gun at 2,000 yards.

The contemplation of this riddled-plate of six inches of solid iron again forces the question upon us, "Where are we to look for resistance to shot if not to increased thickness of the iron plating?"

There can be little doubt that since every armor-plate must have a cushion of some sort between it and the ship, that this *cushion* or *backing* is the source whence increased resistance is to be obtained. In the shed adjoining that in which this Bellerophon plate is exhibited, this principle of improving the backing has two exponents. A plan of corrugated steel plates is shown by Mr. George Redford of London, the resistance of which has not yet

been tested by experiments; but the trials of steel armor-plates which have been made from time to time, hold out little hope that steel in any shape exposed to the impact of shot will give a superior or even an equal resistance to iron.

The other plan is that of Mr. Chalmers, already referred to, whose original target was faced with hammered plates of only $3\frac{3}{4}$ inches in thickness. As the comparative resistance of the $3\frac{3}{4}$-inch plate on a compound-backing and the six-inch plate on a timber backing will help to answer the question proposed, we give the following from the *Times*. The writer, in summing up the results of the Bellerophon trial, ascribes to the target, "a victory almost as great as that achieved by the target of Mr. Chalmers."

"In estimating the relative merits of the two targets," says the *Times* "it must not be forgotten that Mr. Reed's target is larger by some forty superficial feet than Mr. Chalmers's. In thickness of metal it is 20 lbs. per square foot heavier and its cost of construction is £400 more. To these facts we may add that Mr. Chalmers's target was assailed with 15 rounds more than were fired at Mr. Reed's yesterday—15 rounds which were fired with 150 lbs. of powder and threw no less than 1500 lbs. weight of metal against the target of Mr. Chalmers, more than were fired against that of Mr. Reed."

The comparisons drawn from the experiments by the Iron-plate Committee are equally conclusive on the subject of improving the backing. During the present year the old "Chalmers target" was, (after resisting 45 rounds) attacked by shot similar to those employed in rounds three, four, five and six, of the foregoing table, save that in this case a 7-ton gun was used instead of the $6\frac{1}{2}$-ton naval gun, and a stronger brand of powder, which gave an average velocity of 100 feet more per second, with a proportionate increase of *work*. The shot, according to the published reports, failed to penetrate the target, which is 24lbs. per square foot lighter than the "Box target" covered with the Bellerophon 6-inch plate.

If thickness of plate and perfection of manufacture could secure immunity from penetration, the plates exhibited in this shed by Sir John Brown and Co. of the Atlas works, Sheffield, are well calculated to inspire confidence. Here is a 6-inch plate, 30 feet

long and 3½ feet wide, and a massive slab 13½-inches thick cut from the solid shield used in the granite casemate at Shoeburyness. But a visit to the Government shed hard by, at once destroys the feeling of security inspired by the contemplation of these ponderous masses of iron. There the counterpart of the 6-inch plate is shown riddled and torn to fragments by a comparatively light gun with 22lbs. charges of powder ; and the identical 13½-inch shield is shown broken in two, by a few taps from projectiles less than half the weight of our 15-inch shot, and with less than half the work that can be got at 1,000 yards from our 15-inch smooth-bores. We by no means wish to detract from the value of these ponderous forgings, or the credit due to those who have produced them. Our object is to arrive at a true estimate of their worth as a means of defence, and to keep in view the fact that thinner iron, *properly backed*, would give an equal—perhaps a better protection at less than one-half the cost. Quite recently the Atlas Company have excelled all their previous productions by the successful manufacture of a plate of twenty-one tons, over twenty feet long, four feet wide, and fifteen inches thick.

The following extracted from a description of the operation in the *Times*, is interesting if only to indicate the cost at which such plates are produced. After a graphic description of the foundry and the process of "drawing" the plate, the writer goes on to say,

"A great deal of the success depends upon the time at which the plate is drawn, and the amount and length of time to which it is to be heated. All this is regulated by the chief roller and furnace-man who are paid wages which many eminent professional men might envy—wages amounting from £1,200 to sometimes £2,000 a year. . . . . The required dimensions were obtained, as we have said, by less than a quarter of an hour's rolling, and a plate 15 inches thick, the product of the labour of nearly 200 men, and the consumption of nearly 250 tons of coal, was shot out by the rolling mills and left to cool."

The Atlas Company also show specimens of spherical steel shot from 7 in., to 20 in., diameter, the largest weighs 1,155lbs.

Two naval temples of equal size stand on the banks of the Seine, one above and the other below the *Pont d'Iena*, the

former dedicated to the naval display of France, the latter to that of Great Britain. As the French marine models have been mentioned already, it remains only to say that the building on the Seine is almost wholly occupied with the engines and boilers intended for the iron-clad frigate "Friedland." It is not our province to discuss these or any other marine engines, but there is a novelty about the Friedland's engines, combined with the facts that they are the exponents of the principle of construction adopted at the instance of M. Dupuy de Lôme for the engines of most of the ships of the French navy, and that they are the only large marine engines exhibited in motion, may justify a few extracts having reference to the principle on which they are constructed.

"The French three cylinder engines," says *Engineering*, "take their steam direct from the boiler into the centre cylinder only, and expand thence into the two contiguous cylinders, all three being of the same diameter, and having the same stroke of piston. It is an object, in expanding, to obtain as nearly as possible the same mean effective pressure per square inch in the three cylinders, and this is attained in M. Dupuy de Lôme's engines by regulating the point of cut-off and the angles of the three-throw cranks with respect to each other. So far from being equidistant from each other, as so many cursory observers have supposed, the cranks of M. Dupuy de Lôme's two expansive cylinders are but 90 deg. apart from each other, while that of the intermediate high-pressure cylinder is 135 deg. from either of the others. With 25¾ lb. steam in the boilers, reduced to, say, 25lb. at the middle cylinder, and cut off at five-sixths of the stroke, the steam is first expanded into one of the side cylinders and then into the other, and, when the back pressure on each of the three pistons is measured, it is found that the mean effective pressure upon the three pistons is practically the same. . . . . The steam enters the cylinders through what in other engines would be the exhaust port. The live steam enters the cylinder from the *inside* of the slide-valve, the exhaust being effected by the outer edges or ends of the valve. The steam, furthermore, on its way to the middle cylinder, passes around the two expansive cylinders, thus keeping them hot with steam of a much higher pressure than that worked within them."

Many eminent American engineers hold the opinion that the division of power and multiplication of parts, consequent on the use of *two* cylinders, is justified only by their greater certainty in starting or reversing as compared with a single cylinder. In

either the single or double cylinder engines full advantage may, in an emergency, be taken of accumulated steam, "but," says *Engineering*,

"A great defect of this French system is that the expansion is invariable, and that the three cylinders cannot be made to work up steam, each on an emergency, as in chasing, or escaping, or ramming, of full boiler pressure, or nearly so. If, too, the ship is to work with half-boiler power, no advantage can be taken of increased expansion, but the steam must be throttled, and the same rate of about two-and-a-half-fold expansion maintained."

These engines of 950 nominal, are intended to work up to 4,000 indicated horse-power, and they weigh with full boilers 800 tons. The crank shaft is connected to the four bladed screw by an universal joint, an improvement by which the heating of journals, will in a great measure, be prevented.

Below the bridge of Jena, we enter the building which contains the British naval display, a marine museum grand in its proportions, carefully arranged and complete in all that is necessary to illustrate the English idea of a modern man-of-war.

We take the opportunity here to express our deep regret that the United States War and Navy Departments have not sent to this Exhibition a selection of war material, such as would indicate the progress made in our country in ordnance, projectiles, and naval construction. A series of models, such as we have at Washington, would have done us great credit, and would have afforded our people a better opportunity of competing with French and English ship-builders and ordnance manufacturers in supplying munitions of war.

On the wall, facing the main entrance of the British naval shed, the Admiralty alone show upwards of 100 half-block models of ships, arranged and classed according to their respective dates of construction, and the type or rate of each ship they are intended to represent. They show besides about 20 or 30 models in section; and the exhibits of private firms are both extensive and varied. All this is in strict keeping with the genius and aspirations of the British people. "If" (said one of their leading newspapers lately) "we have any strength at all it is at sea. If we have any means of maintaining, not only our position among our equals, but our

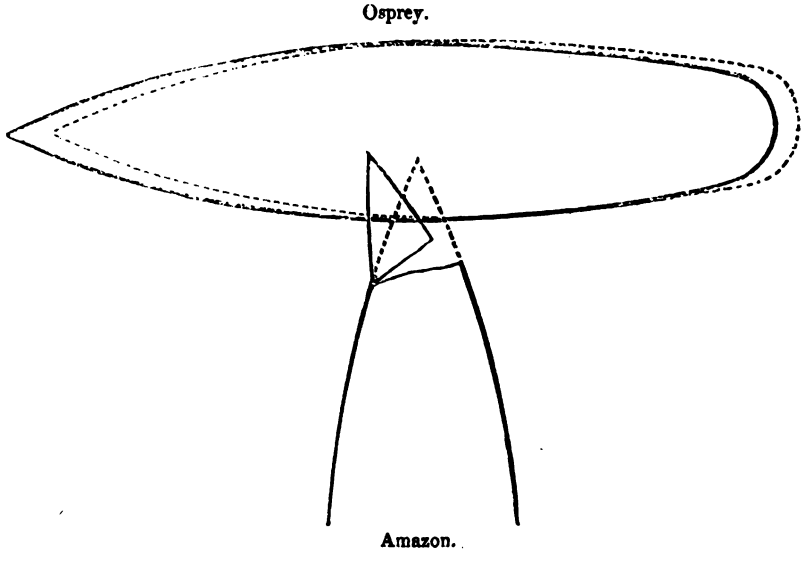
independence, it is in our ships. We are not great in land armaments as our rivals are. We cannot equal them in powerful armies and in military capacity. We have only the sea as our battle-ground, and maritime skill is our national defence."

Half a dozen years ago when "La Gloire" and the "Warrior" were new ships, when Palmerston Forts and the French invasion formed the chief topics of interest in the London journals, the English navy was compared or contrasted with that of France alone. But all is now changed. British ships and guns are contrasted still, but American Monitors, and Rodman smooth-bores have taken the place of the ships and guns of France.

The long continuance of the *entente cordiale* with the latter country, has led the English people to look across a broader sea than the English channel for a probable maritime foe. This, in connection with the more significant fact that the United States has never had any other enemy at sea, cannot fail to make the English naval display in Paris interesting to Americans.

It is not, however, our intention to notice in detail this extensive collection of models or even every class which they represent; some idea of the perplexing, and doubtless unnecessary, variety of ships in the British Navy, may be drawn from the fact that each of the 102 models exhibited is different in some respects from all the others. When there are two or more ships of a class, only one model is shown, thus the model of the "Warrior" is also the model of her consort the "Black Prince." The converted wooden ships of the "Royal Oak" class, four in number, are also represented by one model, and so with the ships of the "Alabama" class, vessels of 1,081 tons. These, six in number, are represented by the model of the "Amazon," which was sunk in the channel in July, 1866. Here, *en passant*, let us for a moment consider the loss of this vessel in connection with the ram principle of attack. The "Amazon," it is true, was a wooden ship, but she was fitted with a projecting prow, armed with a strong cleaver of cast-brass for the purpose of being used as a ram if occasion required. If she was, comparatively speaking, a small ship of war, the vessel she ran into was only a small coasting steamer of less than half her tonnage. Hence it is reasonable to conclude that the project-

ing prow of the "Amazon" was as formidable to the "Osprey" as that of the "Bellerophon" would be to the "Miantonomah," and that it would, in proportion to the weight of the ship, be as strong as the prows of iron-built and iron-plated ships generally. When the "Amazon" ran into the "Osprey," the latter was steaming across her bows at the rate of about ten knots an hour, and the effect of the collision will be understood by the following lines:—



The most prominent instances of ramming that have occurred since armored ships were built, have happened in cases where the ship attacked was either at anchor or going at slow speed. If a ship of the "Minotaur" or "Bellerophon" class, were to run square into an iron-clad crossing her bows at ten knots an hour, it is quite likely that, as in the case of the "Amazon" and "Osprey," they would both go to the bottom. The water-tight compartments of the ram would doubtless save her from such a fate, if she were to strike at a speed of five or six knots. But to get a blow at a ship going at the rate of ten knots, it would be necessary to surpass her in speed, in which case the shock would be sufficient to rupture her own bulk-heads, if not to tear her engines from their bed.

Passing by the models of the wooden three-deckers and other timber-built ships as either obselete or too well-known to be dis-

cussed here, we come to the armored "Warrior," Britain's first iron-clad. The nature of her armor has already been noticed, and a thin red line on the model denotes how far that armor extends. The "Warrior," a ship of 6,109 tons, is 380 feet in total length, and the sides are protected in midships throughout a length of 203 feet, leaving 81 feet forward and 96 feet aft, without any other protection than her iron skin of ½-in. plate. The plated battery protects twenty-six of her forty guns, the remaining fourteen being in her unprotected ends. Her fore and mizen masts will indicate sufficiently above the smoke of battle the position of this armored battery. The armament of the "Warrior" consists of thirty-six 68-pounders and four 40-pounder Armstrongs, an armament too light to fit her to cope successfully with iron-clads even of her own class. To work her broadside guns effectually, a considerable free-board is necessary, and this is dependent on the safety of her unprotected ends. These penetrated between wind and water, which can be done by naval ordnance of any calibre, and the "Warrior" would settle down till her port sills would only be a foot or two above water and the ship herself quite unmanageable—in short—water-logged. A few extracts from the "opinion of Rear Admiral Dacres" regarding this and other British iron-clads, contained in a return to an order of the House of Commons (March, 1867), will enable us to form an estimate of their qualities as ships of war:—

"Without entering into the time they ('Warrior,' and 'Black Prince,') take to wear, or stay under sail—which defect is obviated by using steam to assist the manœuvres, and steam must always be kept ready for that purpose, whether in crowded waters like the Channel or in blockading an enemy's port, I will at once state that I have seen the great difficulty that is always experienced, even by skilful and practised officers, in taking up a berth in a tideway under steam; the risk incurred in putting into such harbours as Cork and Lisbon, except with an ebb tide, which arises from their great weight necessitating their being brought head to wind or tide before anchoring, and the positive danger that would attend entering any crowded harbour with a squadron of such ships, where there might be no room either from the number of vessels at anchor, or the vicinity of shoals, for the ships to round-to, head to wind, to take up their berth.

"Another and serious defect is, that they are dangerous in scudding; the 'Warrior' on one occasion came up nearly eight points against the helm.

"My observations of these vessels have been hitherto in circumstances of comparatively moderate weather: of their probable qualities and behaviour in a heavy gale I am not inclined to think highly. Rolling 52° with a very quick motion as I believe the Warrior did on her passage to Lisbon in January, 1862 is a severe trial for any vessel, though, in justice to the constructors, I must say that in general weather they are remarkably steady, and only in a really heavy sea would they show these uneasy propensities. Their length and want of buoyancy, even with their unarmored ends, subject them to shipping water through the stern cabin-windows in circumstances of wind and sea, when in a wooden vessel no one would think of putting in a dead light. This fact, and the undoubted superiority in buoyancy of these light-ended ships over the 'Hector,' 'Prince Consort,' and 'Research' classes, makes it a question for very serious consideration, whether any of our iron-clads that may be required for service beyond that of block ships in the Channel, should be completly armor-plated, forward and aft, except by a belt at the water-line.

"As the speed of a steam fleet is only equal to that of its slowest ship, so the recent evolutions with ships of such different length and form have gone far to show that the rapid manœuvring of a fleet must be regulated by its largest ships, for the diameter of the circles described by 'Black Prince' and 'Warrior' being, say 1,000 yards at moderate speed, a fleet of which they form part must move in circles with a radius of 500 yards instead of about 250, which could be done by vessels of the length of, and steering as readily under steam as, the 'Hector:' but to convince of the unhandiness of these vessels from their length with the present means in our power of steering ships, I need only add, that where other vessels require only to be two cables apart, the 'Warrior' and 'Black Prince' must be kept four cables."

Leaving the "Warrior" and "Black Prince" we come to the "Hector" and "Valiant" ships, plated on the same system, and with the ends similarly exposed. They are of 4,089 tons, and 280 feet in length. Their armament is similar in its nature to that of the "Warrior," but they only mount thirty-two guns each instead of forty as in the "Warrior." Of these ships Admiral Dacres says:—

"The 'Hector' is, I fear, the worst of the large class of iron ships, although the number of her guns in each broadside has been reduced. She is, I think, when complete with coals and other stores, far too deep to encounter heavy weather, as from her want of buoyancy in moderate weather in the Channel, the sea breaks most uncomfortably up her broadside, rendering the fighting of her guns nearly impossible from the quantity

of water which would be shipped if her ports were open, and would soon flood the decks, and, if not battened down, penetrate below; she pitches very deeply, and is quick in rolling; she is iron-clad from the water-line upwards, which, of course, protects the men at quarters, but leaves exposed her most dangerously vulnerable part,—the water-line, and this, in a ship of her rolling capabilities, would make it easy to sink her, a fate more to be dreaded, than the entrance of shells."

The "Defence" and "Resistance" come next in order. They are also 280 feet in length but their tonnage is only 3,720 tons. Admiral Dacres gives the "Defence" a higher character for sailing qualities than either the "Warrior" or "Hector." He says:—

"She has always been as handy in stays and in wearing as anyone could desire, and is in fact a safe vessel, under all circumstances, of such weather as I have seen her in. She can at all times be trusted with her screw up; under steam she is a serviceable good vessel, expending comparatively little coal. . . . . For all varieties of general service, I prefer the 'Defence' and 'Resistance' to any of the iron-clads I have seen. The defects are the exposed stern and rudder; the first might be remedied so far as to prevent the lightest shot penetrating, cutting her wheel ropes, and injuring the head of her rudder on board. The wheel ropes are so led, that one shot would cut all parts."

There is another defect of those ships that seems to have escaped the notice of Admiral Dacres, and which was forcibly pointed out by Sir John Pakington, in the House of Commons. We allude to the fact that without the buoyancy of their unprotected ends, these ships would sink. These partially armored ships have water-tight bulkheads separating that portion of the hold which is unprotected, from the protected part, so that, though the stem and stern of the "Warrior" and "Black Prince," "Hector" and "Valliant" were shot away, or the fore and aft compartments filled with water, the ship would still float. But not so with the "Defence" and "Resistance." After these ships were designed on similar principles to the others, which would have enabled them to float with the end compartments filled, the Lords of the Admiralty, on their own responsibility, reduced the length of the protected battery to such an extent, that now the safety of these ships in battle will depend on a plate of iron so easily ruptured, that an awkward blow from her own anchor, swinging at the cat-head, broke in the bow of the "Defence."

The "Achilles" closes the list of ships with the Warrior armor of 4½-inch plating and 18 inches of teak backing. She is a vessel of 6,121 tons, 380 feet in length, and is plated almost throughout. Her armament consists of eight 6½-ton 9-inch smooth-bore guns, and eight 6½-ton 7-inch rifled guns, on her main deck, and four of the latter on her upper deck. Her guns, unlike those of the other ships of her class, are able to penetrate such armor as her own. To this ship Admiral Yelverton (in a Report included in the aforementioned Order) ascribes the first place among the British iron-clads. He says:—

"This remarkable ship, so grand and imposing in appearance, will, no doubt (when her masts are properly placed), realise all that has been expected of her as a sailing ship. As a fast and powerful steamer, she takes her place in the highest rank, and combines sailing, steaming, and fighting qualities such as none of the others possess. Her power of going to windward in a breeze when her propeller is disconnected is astonishing, and her stability very great. In running before the wind she does not accomplish what I expected of her, but it is hardly fair to judge of the sailing qualities of a ship with her foremast placed where it now is. When under steam in the trough of a heavy Atlantic swell, her rolling was trifling compared with that of all the other ships of the squadron. On the 17th October, when the 'Lord Clyde' was rolling 26 degrees, and the 'Caledonia' 28 degrees, the 'Achilles' was only rolling 12 degrees. Again, on the 15th October, 'Caledonia' was rolling 14 degrees, 'Lord Clyde' 10½ degrees, and 'Achilles' only two degrees. . . . . We must not, however, lose sight of the fact, that, with all her good qualities, the 'Achilles' is, from her great length, most difficult to handle; and this defect in action, more especially if engaged with a turret-ship, might be her ruin.

"It is, perhaps, going beyond the bounds of what is probable, but I feel certain that this ship might, and probably would, have to go out of action to turn round, thus exposing herself, in almost a defenceless position, to the fire of more than one of the enemy's ships. In the full speed trial of steam she beat the whole squadron considerably."

Without dwelling longer on the sailing qualities or other features of these seven ships of war, we append a table of a few rounds that have penetrated their representative target; passing over all rounds fired by guns of larger calibre than seven inches, observing

merely, that a shell fired with a 70lbs. charge from the 13-inch Armstrong burst in the target and passed clear through, one of the armor-plates being completely blown off. The rounds in the table were fired at 200 yards range:

Rounds.	Gun.	Charge.	Projectile.		Striking Velocity.	Work in foot-tons.	Remarks.
			Nature.	Wght.			
	7-in. M.L.	lbs.	Cylindrical	lbs.	ft.p.sec		
No. 1	(Church)	25	steel.	100	1555	1677	Complete penetration, shot picked up 44 yds. in rear after passing through mound of sand.
„ 2	do.	20	do.	„	1411	1374	Complete penetration. Shot went out to sea.
„ 3	7-inch "Shunt"	25	Round-hded do.	„	1531	1625	Struck rib. Complete penetration. Shot went out to sea.
„ 4	do.	do.	do.	„	do.	do.	Complete penetration.
„ 5	do.	do.	Elliptical-headed steel	101	1498	1572	Complete penetration. Shot broke up.
„ 6	do.	do.	Cylindrical "chilled"	102	1500	1555	Do. Do.
„ 7	7-inch. "Woolwich"	25	Solid headed live shell.	„	1539	1686	Through, setting fire to backing; head of shell out to sea.
„ 8	7-inch, Lancaster	do.	Concave headed shell.	137	1418	1731	Complete penetration.
„ 9	do.	17	do.	„	1220	1117	Do. Do.
„10	7-inch "Whitworth"	23	Flat headed steel shot	140	1270	1443	Do. Do.

From these ten rounds we perceive that an average work of 1500 foot-tons overcame the Warrior armor. But a more remarkable round than any of the above was fired from the Whitworth 7-inch gun at this target, after the four and a half inch plates had been replaced by others five inches thick. This round was fired at 800 yards range with 27lbs. of powder. The projectile was a flat-headed steel shell of 151lbs. weight, had a striking velocity of 1,165 feet per second, and 1,421 foot-tons of work. It completely penetrated the target, bursting in the backing and carrying many splinters inside.

We have already referred to the retrograde step taken by the British Admiralty in the armor of the "Minotaur" class. Imposing in appearance, and costing about £2,500,000 each, the "Minotaur," "Agincourt," and "Northumberland" are perhaps the least efficient ships of war in existence. They are built of iron and are completely armored with 5½-inch plating amidships, and 4½-inch plates at the stem and stern, upon a backing of timber of an average thickness of 9 inches. In resistance to shot, they are believed to be inferior to the "Warrior" class, but the reports and transactions of the Iron-plate Committee afford no data by which the resistance of these ships can be fairly compared. The following particulars of one round fired at each target may give an approximate idea of their respective powers of resistance:

Target.	Gun.	Charge.	Shot.	Velocity.	Work.	Effects.
Warrior	10·5 in.	50 lb.	Spherical cast-iron.	1620 ft. per sec.	2730 foot-tons.	Penetrated plate, and 13 inches of the backing bulging inner skin.
Minotaur	"	"	"	"	"	Penetrated plate, lodged in backing, broke two ribs, and seriously bulged inner skin.

It must be borne in mind that the latter round was fired at a new target, while the "Warrior" target had previously received forty-five rounds. Owing to the greater thickness of the Warrior's side, the effect of the blow is distributed over a larger area, and in the ab-

sence of reliable experiments, it is reasonable to conclude, with the Iron-plate Committee, that the resistance of these ships of the "Minotaur" class has been greatly impaired by the substitution of an inch of iron for 9 inches of timber. The "Minotaur" is a ship of 6,621 tons, and 1,350 horse-power. She is 400 feet in length, and in the matter of handiness and sailing qualities will probably rank with the "Warrior" and "Achilles." Our 11-inch smooth-bore with 40lbs. charges would easily penetrate the sides of the "Minotaur" and her consorts at 300 or 400 yards, while the 15-inch gun would do the same at 1500 yards with 60lbs. of powder; and if the same charge were used, as that lately employed at Shoeburyness (100lbs.) this gun would send its shot through the "Minotaur," "Agincourt," or "Northumberland" at 3,000 yards.

Time and space would fail us were we to speak of all the classes of iron-clads in this collection, so, leaving for the present the smaller vessels of the box battery class, we come to the "Bellerophon," which is believed by Englishmen generally to be the most powerful iron-clad afloat. In resistance to mere penetration she is equal, perhaps superior to the "Warrior," but her want of a *cushion* or elastic backing will cause her to suffer more from the smashing effects of heavy shot. We will endeavour to explain this when speaking of the "Hercules," which is in most respects a sister ship. In regard to the area protected (in this model the thin red line to indicate the extent of armor is wanting) the "Bellerophon" is inferior to the "Warrior," her protected battery being 90 feet in length to 203 feet in the "Warrior." With the exception of a belt of plating reaching a couple of feet above the load water-line, her sides afore and abaft the 90 feet battery are wholly unprotected. They have the disadvantage, as compared with the unarmored parts of the "Warrior," that the skin is thicker, thus affording more metal to be converted into langridge under the impact of light ordnance or grapeshot. A round or two of case-shot (such as we have suggested when speaking of projectiles), fired from a 15-inch or 20-inch smooth-bore into the unarmored ends of the "Bellerophon," would doubtless consign her to a similar fate to that which overtook the "Affondatore," or the partially-armored "Palestro" at Lissa, which was set on fire

and finally blown up in consequence of a shell exploding in her unprotected cabins.

If, according to Admiral Dacres, "the speed of a steam-fleet, is only equal to that of its slowest ship," the strength of a ship of war may be said to be equal to its weakest part. Viewed in this light the "Bellerophon" is inferior as a fighting ship to the "Minotaur," or even to a wooden frigate of equal speed and capacity. The "Bellerophon" is a ship of 4,270 tons, carrying engines of 1,000 nominal horse-power. She is 300 feet in length—nearly 100 feet shorter than the "Achilles," a wholly armored ship. As the armor for the Bellerophon was sacrificed to secure handiness and speed, we refer to the opinion of Admiral Yelverton on these points.

"I cannot," he says, "call the 'Bellerophon' a handy ship, for she possesses the defect common to all iron-clads, viz., that she will not pay off with certainty in spite of her after-yards being square, and helm up; and she is very doubtful in stays, even under the most favourable circumstances of wind and sea, having observed her miss stays three times on one occasion, and at length obliged to wear. This I attribute to the balance rudder, which may be well suited to a screw steamer, but seems to have a tendency to stop the ship's way too suddenly under sail, and she then refuses to come head to wind. Whatever may be the merits of the balance rudder, it has the great defect of offering a target of very large dimensions. The captain of the gun who would fail (at moderate range) to hit it, when the 'Bellerophon' pitches, must be a bad shot. Under all the circumstances of steaming, I think the 'Bellerophon,' ranks below the 'Lord Clyde,' and on a par with the 'Ocean' and 'Caledonia.' In this respect I was disappointed, for I expected much greater speed."

The smaller ships of the box-battery class will be fitly represented by the "Research." They are either wooden or composite ships, and have a small battery of about 40 feet in length protected by iron-plating of about 4½ inches in thickness. Armor-plated bulk-heads connect the ends of these batteries, thus forming a square box-shaped enclosure amidships, similar in principle to the French frigate "Marengo." A belt of armor-plating about four feet wide—three feet below and one foot above the water-line—runs around the ship, the remainder of the side above water

being unprotected. Speaking of this ship, Admiral Dacres in his Report says:—

"The great defect of the plan of a box for the gun appears to me to be

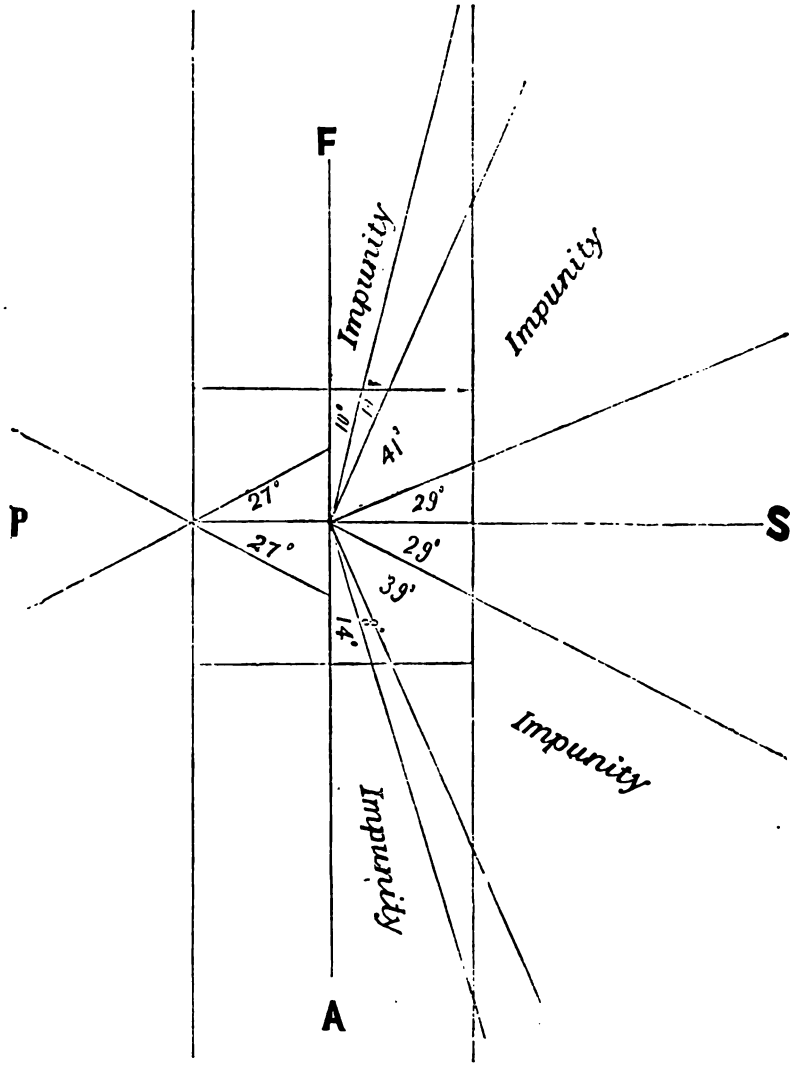


Diagram showing the angles of training of a ship of the box-battery class, and the points of impunity from which she may be attacked.

the number of points which are left for an active enemy of more speed to attack with perfect impunity; a diagram of the training of the guns at

once shows this. Copies of these, given to me by Captain Wilmshurst and Commander Rowley, are enclosed.

"At a recent inspection at Portland, the 'Frederick-William,' at two cables' distance from the 'Research,' could not have been struck from the gun on the after broadside port, or by the same gun when shifted to the stern battery port on the same side of the ship.

"She might I think, be easily carried by boarding, and if the enemy once obtained possession of the battery decks, shells or lighted canvas thrown down the hatchway would carry the ship.

"Clearing away the bulwarks for action takes too long a time. From the effect of a moderate sea on the port gate of the 'Research' in the last cruise, I have no confidence in its power of standing the shock of a heavy sea."

Passing the "Waterwitch," "Pallas," and a fleet of fancy vessels our attention is attracted by the models of the "Monarch" and "Captain," turret ship, and turning to the official catalogue we find the following interesting parallel :—

	Tons.	Length.	Draught. Fore.	Aft.	H. Power.	Estimd. Speed.
"Monarch."	5,100	330ft.	22½ft.	26ft.	1,100	14 Knots.
"Captain."	4,272	320ft.	22½ft.	3½ft.	900	14 do.

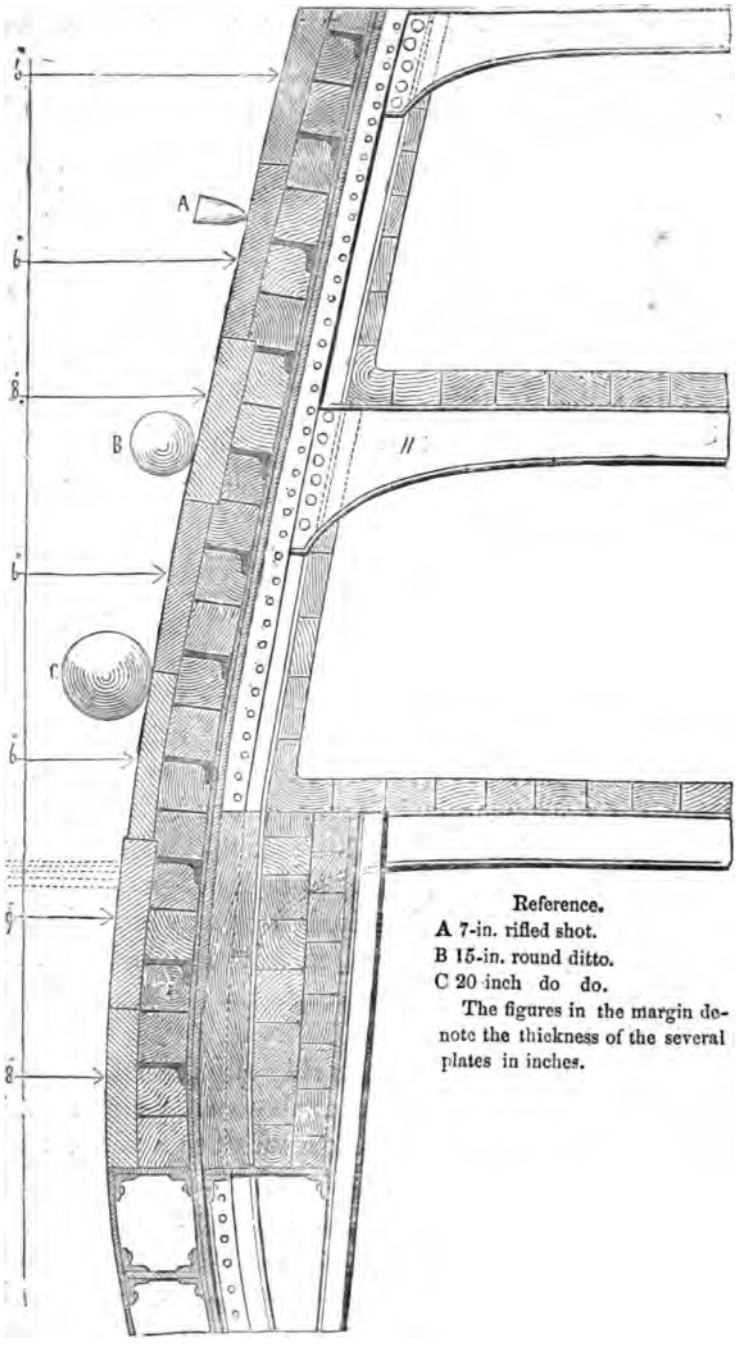
Armament in both cases, four 22-ton guns, and two 100-pounders.

The former was designed by the Controller and Chief Constructor of the Navy, and the latter by the Messrs. Laird and Captain Coles.

With a few words about the "Hercules" models we close our inspection of this highly interesting naval display.

It would be difficult to imagine a case of more successful deception than that by which the British public has been led to believe that the armor-plates of the "Hercules" are nine inches in thickness. A target faced with an 8-inch, and a 9-inch plate, was set up at Shoeburyness and called the "Hercules target," and a full-size section of similar armor is shown in the Exhibition, ticketed "Section of Hercules target." True, a section on a scale of ½-inch to the foot is exhibited in a glass-case, which shows the actual armor of the ship, but the full size section takes the eye, and leaves an impression which cannot easily be effaced. We

"Hercules" Armor. Scale ¼-in. to foot



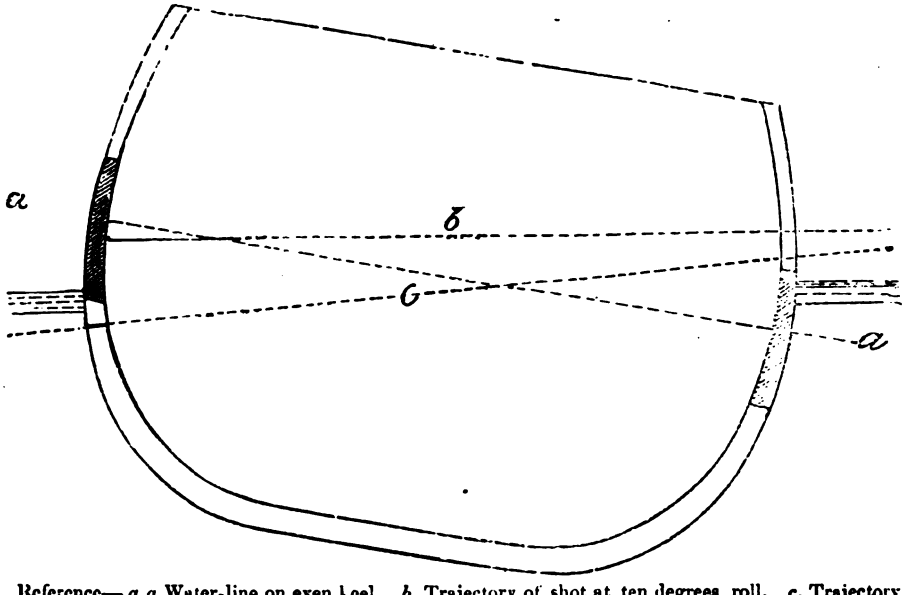
Vertical Section.

never remember having seen in any British journal, any notice of this ½-inch scale model. Indeed it is doubtful if any of the conductors of the press, from the *Times* to the halfpenny weekly, are aware of its existence, or that the armor-plating of the "Hercules" is other than nine inches thick. Our woodcut, on a scale of ¼-inch to the foot, will show that the armor plates of the "Hercules" are the same thickness as those of the "Bellerophon." She has, it is true, a 9-inch belt at the water-line, and an 8-inch belt on the line of the main deck beams, but the plates which protect her battery and lower deck are only 6 inches thick. These plates have a backing of 12 inches of timber with a plentiful supply of stringers, after the plan of the Chalmers target. This backing rests on a double ¾-in. skin supported by the usual iron framing. The foregoing table, of eight rounds fired at the Bellerophon plate, will give a fair idea of the strength of the greater part of the "Hercules" armor. We find that a chilled shot fired with 22 lbs. of powder, and carrying less than 1,500 foot-tons of work, defeated the "Bellerophon" plate on a much stronger backing than that of the ship itself. Hence, allowing for the extra two inches of backing, the "Hercules" would give way before a 7-inch rifle with a charge of 25lbs. and a power of 1,700 foot-tons, an amount of work which leaves a great margin in favor of our 15-inch guns with battering charges. There can be little doubt that the water-line belt would prove too strong for the 15-inch gun, as it did for the 600-pounder Armstrong, but shot fired from an elevated position, or when the ship rolled more than ten degrees, could enter above the water-line belt and pass out through the other side below it, as shown in the following diagram.

The chief defects however of this ship and the "Bellerophon," are the unprotected ends, and the absence of any *cushion* to neutralize the vibration, when struck a racking blow on the side. The armor-plate (see woodcut of "Hercules" armor) bears on the horizontal stringer opposite shot B; this stringer rests on the iron skin which in turn is rigidly connected with the ship's frame and the beam H. Now the 15-in. shot B, striking the plate with a remaining force (at say 1,000 yards range) of 4,000 foot-tons, would, if it failed to penetrate, paralyze every man on the gun

deck in the region of the blow. At Lissa, a ball struck one of the iron deck-beams of the "Affondatore," and broke it asunder, as if it had been a lath of wood. A steel shot of 490lbs. in weight, would probably bend the beam and raise the deck, so as to render

Water-line-belt Iron-clad, rolling twelve degrees.



Reference— *a a* Water-line on even keel. *b*. Trajectory of shot at ten degrees roll. *c*. Trajectory at fifteen degrees.

it difficult, if possible at all, to work the guns. But such a blow, though it might not prove fatal to any one, would doubtless disable, for a considerable time, all within a certain radius of the point of impact. Let any one who may desire to test on a small scale the effects of such a blow stand on a plank of timber, and get some friend to strike the end of the plank sharply with a sledge hammer. A pointed projectile would not produce this paralysing effect. It insinuates its fine point into, and through the iron-plate, breaking itself to pieces in the act, and if there be a good depth of backing to absorb the pieces, it will prove a comparatively harmless missile. Against the thin sides, however, of the "Hercules," "Bellerophon," and British ships generally it would prove very destructive. The ogival-headed shot, as it does not rack like spherical shot, is not so hard on the fastenings. Since

the introduction of these projectiles at Shoeburyness, fewer bolts have been broken than under the racking and buckling effects of round shot.

The two fore and the two aft guns of the "Hercules" battery, are so placed, that they can fire at a slight angle, about fifteen degrees, from the line of the keel. This improvement, however, has its defects; it necessitates the scooping out of large hopper-like recesses in the ship's sides, each of which will serve to collect, and direct into the battery, a shower of grape or case shot, so as to rake every gun on that side of the ship. This arrangement is demanded by the new tactics for fast iron-clads—"to fight end-on and choose their distance"—or in other words, to dodge and run away. These tactics imply sea-room, fine weather, and the finding of the enemy when and where it would be most convenient to fight him, circumstances not always come-at-able. Nelson, who used to observe, that "Nothing is certain in a sea-fight above all others," like Paul Jones, and other naval heroes had often too much trouble to *find* the enemy, to be particular about *when* and *how* they were to fight him.

Respecting the sailing qualities of the British iron-clads, very little can be said, save what is put on record by their own officers. Almost every day we read in the English papers of the American iron-clads being unseaworthy, though several of them have crossed the Atlantic and cruised in the Pacific, while no British armored ship, except the partially-armored "Favorite," has cruised in American waters, or visited the Pacific or Indian Oceans. The following extracts from the Reports of Admirals Yelverton and Warden, commanding the Channel fleet, during the experimental cruise of last year, will be read with interest:—

"On leaving Portland, September 20th, the wind was fresh from the westward, and had been blowing hard from that quarter for several days; I found a very heavy sea and swell to the westward of the Lizard, so much so that I decided not to attempt to beat against it, but try the merits of the ships, simply as steamers proceeding under adverse circumstances to a certain point, maintaining a given moderate speed, and preserving, as near as possible, their exact formation in order of steaming, so essentially necessary for the performance of such steam tactics as might be required, had we been in search of an enemy

"I may here mention that the cruising ground in the Atlantic selected for our trials was, for the object of meeting very bad weather, somewhat too far to the southward, as from the fall of the barometer, the state of the sea and general appearance of the weather, I have no doubt that on three occasions heavy gales passed between us and Cape Clear, affording on two occasions only, proof of their strength by the share we got of them."

After referring to the sailing qualities of the ships, the Report says:—

"When the signal was made to get up steam and lay out targets, it was necessary to place the ship's head to the sea before it could be considered safe to send the men aloft to furl sails.

"The precaution was then taken of battening down the main-deck hatchways fore and aft, and as the practice was limited to 15 rounds, five guns only on the port side were cast loose, and the practice commenced.

"It was found utterly out of the question to fire at the target in any other position than when head on to the sea, and the time occupied in firing the prescribed number of rounds was about three-quarters of an hour. It was necessary to steam round the target once or twice to bring the guns to bear when the ship rolled to 28 degrees, whilst it did not exceed 10 or 11 degrees when head to sea. The result was, that the main-deck was flooded with water to the extent of flowing over the hatchways, the water poured in and out of the guns, two shot rolled overboard out of them, and one was followed by the cartridge. Two of the guns at different times got the better of the crew, and banged in and out of the port several times with extreme violence, and two of the slides were to a certain extent damaged by it.

"It is needless to say that the practice was wild in the extreme, nor do I believe that at any time there was the least probability that we could have hit an enemy's ship except by accident or miracle. I did not observe any ship, except the 'Achilles,' fire while in the trough of the sea, but she was comparatively quite steady. I have been since informed that the 'Hector' did so likewise. Nor did all the ships fire the prescribed number of rounds, the "Bellerophon" only two, which shows a manifest desire to to get their guns secured again.

"The result of that day's experience would seem to prove that it is possible (though certainly never desirable) to cast loose and fire these 7-inch guns in a seaway, either singly or a few at a time, with well-trained men or experienced crews; but under the circumstances of that afternoon I hold that it would have been utterly impossible to have gone to general quarters or fought an enemy's ship.

"To have opened all the main-deck ports, judging by the effect of opening

only five, would have been to have washed the men away from the guns, and consequently they (the guns) would have taken charge of the deck by getting adrift, but with what consequences it would be utterly impossible to predict.

The most of the cartridges, if not all of them, would have been destroyed in the guns, and the guns which could have been got off would have hurt nobody. Three times in the course of that afternoon did the ship roll her main chains right under, and threw the water on the upper deck. The lower sills of the main deck ports are about 8 feet 6 inches from the water when she is deep, and a roll of 15 degrees just touches the lower sill, and 22 degrees' roll just about covers the whole part."

Admiral Yelverton, comparing broadside and turret ships, says:

"I do not think that on any future occasion I would venture to open a port or cast a gun loose in any of these ships rolling more than 12 degrees or 15 degrees, for beyond that the practice would be very doubtful, and the certainty of shipping water very great.

"The turret system of arming a ship would have had a great triumph on this occasion, for there is no doubt that a sea-going turret ship, say 12 or 14 feet out of water, would have fought her guns without the slightest difficulty, and have fired easily six shots to every one from our broadside ships.

"Placed as the squadron was on the 26th September, a good turret ship would have been a most formidable adversary, and have done us serious injury."

Having no desire to represent these ships in an unfavorable light, we frankly admit that the foregoing extracts are such as relate to their performance in rough weather. The admiral commanding concludes as follows:—

"It is not fair to expect an iron-clad to be as good a cruiser as an ordinary ship, but if she can keep her position under sail off an enemy's port, without having recourse to steam, and make the best of such weather as she will there find; if her powers of offence and defence in action are equal with what she will meet with on the high seas, and she carries a substantial armament, well mounted, and well out of water, all that could reasonably be expected of her as a cruiser is gained, and we must be content with a good steamer and a stout fighting ship, to the exclusion of a fast sailing one.

"Taken collectively, the ships have formed a very efficient squadron; they have cruised for more than a month continuously, at a stormy period of the year, and with the exception of a few spars and sails carried away, lists of which are hereunto appended, no ship has sustained any serious damage.

"I am not aware that such a result has yet been attained by an ocean cruising squadron of iron-clads of any foreign power."

The data as to their resistance to shot have been derived from various sources—official and semi-official—and used so as to place this quality in its true light. The powers of resistance of each representative target have been calculated to a fraction in a paper read by Captain Noble, R. A., at the British Association (1866), and the value of each ship was estimated by her ability to pass batteries armed with our 11-inch and 15-inch guns. Thus, it is estimated that the "Bellerophon" could pass the forts at New York within 200 yards without suffering except by racking, and the "Warrior" could pass on the same terms at 800 yards. Captain Noble, however, limits the power of the 15-inch gun to a charge of 50lbs. which gives a velocity of 1,070 feet per second and 3,547 foot-tons of work at 200 yards.* But this gun has been fired at Shoeburyness with charges of 100lbs., giving a velocity of 1,538 feet, and 7,405 foot-tons of work, a power sufficient to penetrate, at 2,000 yards, any iron-clad in the British Navy. It must also be borne in mind that, as in the case of the "Hercules," these Shoeburyness targets do not always fairly represent the ships whose names they bear. The "Bellerophon" target, for instance, represented only that part of the ship supported by and below the main-deck beams, while the eight-inch *double-framed* "Warrior" target at which the Rodman gun was fired, is fully twice as strong as the

* Table giving the remaining velocities and work of spherical steel solid shot fired from American 15 in. and 11 in. smooth-bore guns.

Gun.	Charge.	Projectile.		Initial Velocity.	At 200 yards.		At 500 yds.		At 1000 yds.	
		Weight.	Diameter		Remaining Velocity.	Work.	Remaining Velocity.	Work.	Remaining Velocity.	Work.
	lbs.	lbs.	inches.	ft. per sec.	feet.	tons.	feet.	tons.	feet.	tons.
15 in.	50	484	14.85	1,070	1,023	3,547	969	3,152	980	2,599
11 in.	20	189	10.85	1,080	1,019	1,361	936	1,148	818	877

"*Captain Noble, R.A.*"

"Warrior" ship. Apart from the so-called "Hercules" target, that of the "Lord Warden" was the strongest, as it unquestionably was the fairest, of all the targets professing to represent certain ships. The two following rounds therefore will give some idea of the strength of England's best iron-clad:—

Round.	Gun.	Charge.	Shot.	Weight.	Velocity.	Work.	Effects.
1st.	9½ in.	44 lbs.	Cylindrical Steel.	221 lbs.	1450 ft. per sec.	3222 foot-tons.	Through, and 500 yds. out to sea.
2nd.	,,	30 lbs.	,,	,,	1310 ft. per sec.	2642 foot-tons.	Complete penetration.

It must not be forgotten, however, that in England resistance to shot is not considered of the first importance in iron-clad construction. The Duke of Somerset, when First Lord of the Admiralty, at a meeting of the Society of Arts said, "If we are to have 300 or 400-pounder guns, it would be a question with me whether it would not be better to do away with armor-plates altogether and let the shot go right through," and in a curious correspondence (lately published) the Controller of the Navy—the head of the construction department, says, "I have purposely avoided the subject of the relative resistance to shot of the several targets, it has no bearing on the question."* The British

* (Copy.) Admiralty,
January 23, 1864.

SIR,—I do not wish to be uncourteous, and therefore, though I am much pressed for time, I will endeavour to reply to your note of the 18th, marked private.

The *whole question* between yourself and the Admiralty I believe to be simply this—Can a ship be built in accordance with the design you embodied in your target, with ADVANTAGE over the ordinary mode of building armor-plated ships?

I unhesitatingly give you my opinion that it cannot, and I have the best possible grounds for my belief. That you should hold the opposite opinion is quite natural. You cannot shake my conviction; I cannot shake yours; and I really cannot see what is to be gained by any further correspondence or discussion.

I have purposely avoided the subject of the *relative resistance to shot of the several targets*, it *has* NO BEARING *on the question* between yourself and the Admiralty, though I am afraid that my conviction on this head would be found quite opposed to your own.

I remain, Sir,
Your obedient servant,
(Signed) ROBERT SPENCER ROBINSON.

Admiralty demand three qualities in an iron-clad, and in the following order:—First, Speed, second, Handiness, and third Armor. Whether they are right in their classification or not will only be known when these ships come out of action. The British iron-clad navy at present numbers about 30 vessels,* eighteen partially plated, and twelve fully armored. That these ships combined would form a powerful fleet capable of inflicting great damage on a foe cannot be denied, though the fate of the partially armored vessels at Lissa is suggestive of defeat to similar ships elsewhere.

Many of the private cases in this naval shed are deserving of a closer inspection, and more extended review than at this stage of our labors can be devoted to them. Messrs. Laird Bros., of Birkenhead, obtained a gold medal for the model of the "Captain," mentioned in connection with the Government ships. She would doubtless be one of the most powerful iron-clads in Europe, but for her unprotected forecastle and poop; these not only prevent her turret guns from firing directly fore and aft, but are liable to be set on fire, which would seriously interfere with the management of the ship, and possibly lead to her total destruction. To obviate the necessity for using one of her 600-pounders, when a light tap only is required, she carries two 100-pounders, and it would not be amiss in such cases, including that of our own Monitors, to have a gun or two even lighter still. For in firing at an unarmored ship, or the unprotected ends of iron-clads of the "Warrior" or "Belle-

* "The necessity for a better armor for our iron-clads is apparent from two indisputable facts. First the 6½-ton gun, with the moderate charge of 16lbs. of powder, can send the Palliser shot of 115lbs., broken up into ten thousand fragments, through the side of the "Warrior" at 500 yards. Secondly, in a list of thirty of our iron-clads—about all we have afloat—twenty are weaker than the "Warrior" in resistance to shot, five are equal, and four superior. Thus, twenty-six of our iron-plated ships can be penetrated by the 6½-ton gun with a very moderate charge of powder, and the remaining four would be pierced by the same gun and shot by increasing the charge to 22lbs. If, then, every ship we have afloat can be penetrated by this comparatively light weapon, we can imagine the effect of the 12-ton gun, with 250lbs. chilled shot and 43lbs. charge; but no one can imagine the effects of the langridge of these terrible missiles between the decks of a crowded iron-clad, or contemplate the scene without a feeling of horror." —*Extract from a letter in the "Standard."*

rophon" types, it is a waste of power—like taking a sledge hammer to break an eggshell—to use a 15-inch smooth-bore or a 12-inch rifled gun.

In the same case is a model of the "Scorpion" one of the *ci-devant* Confederate rams. The "Wyvern," the mate of this ship, is thus referred to in Admiral Yelverton's Report:

"This vessel could never have been intended as a cruising or sea-going ship, for although she is buoyant and rises to the sea, yet from her being so very low in the water it rushes up her sides over all, and when broadside to the sea it is impossible to move about on her decks without the risk of being washed overboard. At sea she is almost always battened down, to the exclusion of air in the engine-room and stoke-hole."

R. Napier and Son, of Glasgow, show a model of the "Osmanea," "Azizea" and "Orkhanea," frigates of 4,222 tons and 900 horse-power, built for the Turkish Government. They are wholly armored with 4½-in. and 5-in. plates, on a backing of 9 inches of timber—armor quite incapable of enabling them to meet, and successfully cope with any ships of war, save such wooden vessels as attacked and destroyed the Turkish fleet at Sinope.

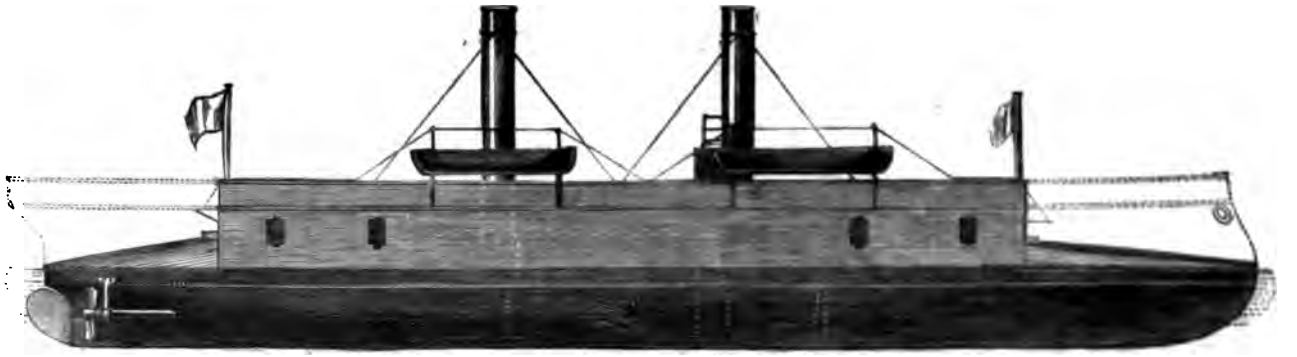
Another and more powerful ship commenced for Turkey, but which has passed into the hands of the Prussian Government, is shown in model by the Thames Iron-works and Ship Building Company. This vessel is of 5,938 tons, and 1,150 horse-power. She somewhat resembles the "Bellerophon" frigate in the principle on which she is constructed, and has a protected forecastle carrying two guns.

A model of an iron-clad gun-boat for Brazil, intended for service in the rivers of South America, is exhibited by Messrs. J. and G. Rennie, of London. Its length is 160 feet, tonnage 1,033 tons, and draught of water 9 ft. 6 in. There are two batteries as shown in the following engraving, one fore and one aft, each battery being pierced for six guns, two on each side and two forward and aft, which enables the vessel to fight end-on, or with her broadside. The batteries are protected by 4½-inch plating, and there is a water-line belt of the same thickness. The sloping decks fore and aft are covered with 2½-in. plat-

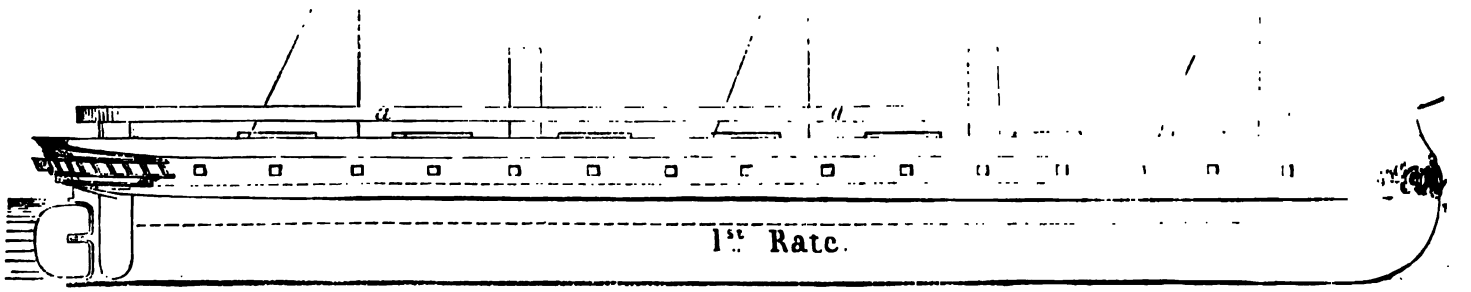
ing. She has twin screws, and the bow and stern were fitted with temporary ends for the purpose of navigating the Atlantic.

Along with several models of frigates and floating-batteries Messrs. C. Mitchell and Co. of Newcastle, exhibit a model of two double-turreted iron-clads, which bear a closer resemblance to our Monitors than any model in the Exhibition. The vessels represented by this model, are the "Rusalka" and "Charodaika," of 1,600 tons and 300 horse-power, built for the Russian Government. They carry two 300-pounders in each turret. These unpretending little craft cost comparatively little at first and are economical in commission. Low in the water they offer an insignificant target to an enemy's gun. With their twin screws they are handy, compared with the three Turkish frigates built in Glasgow, and would certainly be more than a match for them in action, though each frigate cost, at least, four times as much as the Russian Monitor.

In Mitchell's Monitors the aim is to expose a minimum surface to the attack of an enemy, but in the next, and last, collection which we shall refer to the very reverse is the case. We allude to the collection of models exhibited by Admiral Halsted. These are undoubtedly the most exhaustive, the most complete, and perhaps the best finished models in the building. This display is got up not only as a lesson to naval constructors generally, but in the fond hope that the scheme of which it is the exponent, will be accepted as the most certain means of "maintaining future peace on the ocean by navies." This collection does not represent any constructed or even contemplated ship; it is a project, "pure and simple," and certainly if weighty and well-known names, could ensure its success, it will not remain long without being realized. Amongst those to whom Admiral Halsted tenders his acknowledgments for advice and counsel, we find the names of Scott Russell, Isaac Watts, C.B., late Chief Constructor of the British Navy, and Oliver Lang, shipbuilders, while Whitworth, Napier, and Penn have given valuable aid as engineers. The drawings were made by Mr. Henwood, and the models by R. Napier and Co; the turrets and tripod masts had the inspection of Captain Coles himself, whilst the armor, the gun-carriages, the boats and other fittings



Rennie's Brazil Gun-boat.



Halsted's 7-Turret Ship

are the inventions of separate parties, the inventor of the boats being a clergyman of the Church of England. "In the multitude of counsellors there is safety," but sometimes "Too many cooks," etc.

These models are eight in number, each representing a ship of war of a certain "rate," and besides these, there is a section in model, and various models of gun-carriages, turrets, boats, etc. Admiral Halsted, as will be seen by the annexed woodcut of the "first rate," attaches little importance to the twin-screw system, or the triangular ram-prow so fashionable at present. The balance rudder, flush with the water-line on even keel, would like that of the "Bellerophon," offer a large target when the ship pitches moderately. The space included within the dotted lines in the engraving, shows the extent of ship's side to be protected by armor. The main-deck, with its battery of 14 guns has no protection, but whether these guns are intended for actual service, or merely for holiday use and practice, does not appear.* Referring to the spar-deck *a*, Admiral Halsted says:— "It is acknowledged, in sincere obligation, that this most important feature in aid of the whole undertaking, is adopted from the rudimental spar-decks connecting turret with turret, in the American Monitors. And the expansion thus made, of the first idea thus given, is here gratefully offered as a re-payment to be applied, it is hoped, in improved comfort and security to America's own ocean turret fleet of the future."

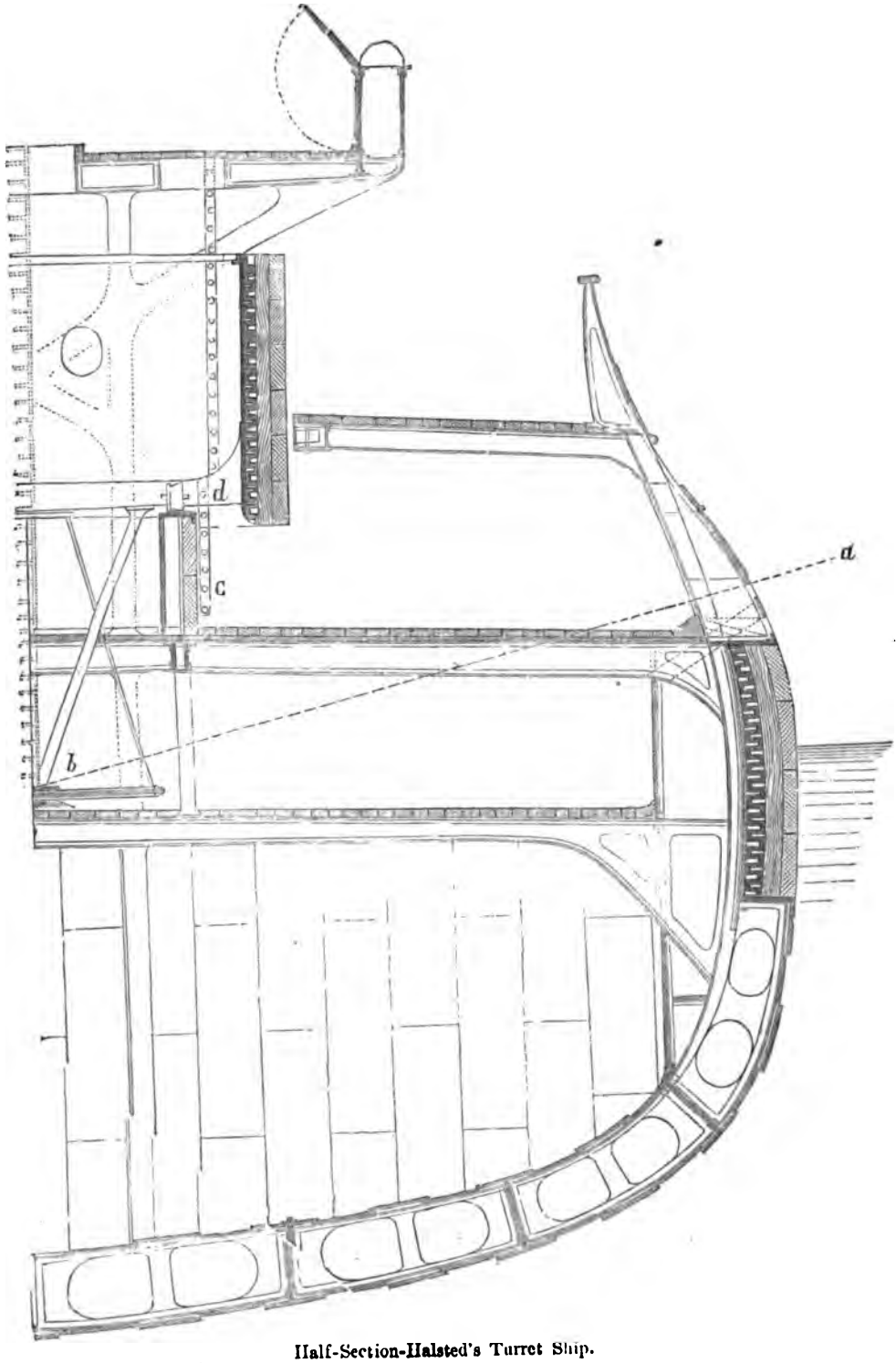
The following engraving of a half-hull section of these ships, which are all of the same character, will show the plan of construction proposed and the nature of their armor. This latter is to consist of a 6-inch plate (same as "Bellerophon" armor) resting upon a timber backing 11 inches deep; this in turn, rests upon stringers of iron rolled in the fashion of the ordinary U-rail for railroads, 7 inches deep. The chief merit of the latter arrangement is that it presents a certain amount of iron edgewise to the blow, as in the Chalmers target. The most obvious defect of the backing adopted by Admiral Halsted, is that the great weight of iron it

* We have learned that these guns are to be used for practice, salutes, and operations on land.

contains offers no support to the armor-plate, thus any shell which can penetrate a 6-inch plate will explode in the 11-inch timber section, and the extra strength of the inner structure will enable the shell most effectually to blow off the armor-plate. The whole arrangement sets at defiance the oldest and best established military tactics. Here the first and second lines of defence, the plate and the U-rail backing, are united only by a plank of timber, and therefore the second line of defence gives little or no support to the first, leaving the structure to be destroyed in detail. The weight of materials in this structure is about the same as in the 8-inch "Warrior" target of which such fearful havoc was made by the Rodman gun, and which has even been penetrated by both shot and shell, from the 9-inch rifled gun.

Notwithstanding the many excellences of these models, the chief defect of the whole scheme consists in offering so large an unprotected surface to the fire of an enemy's gun. The main-deck battery, mounting in the "first-rate" 14 broadside guns, is 9 feet in height, all above the armored belt. "The sides of the main-deck," says Admiral Halsted, "are of ¾-inch plates *unprotected*, the armor being limited to the vital body of the ships, and all connected with turrets. These sides are consequently liable to be riddled with shot-holes through which the water might afterwards flood the main-decks in heavy weather." Here the word "shot-holes" is used, evidently blinking the effects of *shell* which have an ugly habit of bursting, and doing great damage between the decks of unarmored ships. The bursting of a few shells between the main and upper decks of these ships, tearing, up-ending, and setting fire to the planking of the latter, would be a serious obstacle to the training of the turret guns. It is not unreasonable to contemplate the flames communicating with the spar-deck and enveloping the turrets in a sheet of fire, which with the cloud of smoke would prevent any efficient working of their guns, and seriously interfere with the steering and handling of the ship, even if the fire did not entirely consume the vessel.

Again, a roll of 14 degrees, would bring the main-deck port-sills within two feet of the water-line and a shot striking her between wind and water in this position, would, if a flat-headed



Half-Section-Halsted's Turret Ship.

steel shot, take the direction of the dotted line *a b*, (see woodcut) passing, it might be, through amongst her turret machinery, and going out under the armored belt on the other side. None other but flat-ended steel shot or shell would be likely to grip the 1½-inch deck-plate at this angle, but this form of shot would be assisted in its work by the six-inch deck-planking of teak. An ogival, round-headed, or spherical shell would glance along the deck, probably striking the turret machinery shield at C, and bursting upwards through the ladder opening *d*, into the turret itself. Every shell bursting on this main-deck would, doubtless, send a considerable percentage of its fragments through the capacious opening *d*, into the turrets. These ships, as well as those designed by the British Admiralty, have a plentiful supply of crevices and vulnerable points, which their designers fondly expect will not be detected in action. We frankly admit that most of these chinks are such as no gunner would be able to take deliberate advantage of. But we have all read of the king who went into battle secure, as he thought, in his panoply of mail, and that "a certain man drew his bow at a venture, and smote the king between the joints of the harness."

One word more, and we will take our leave of this highly interesting set of models and the ambitious* scheme which they have been designed to carry out.

The arrangement, *en eschelon*, of seven turrets on the deck of one vessel is productive of such confusion in the lines of fire, that some of Admiral Halsted's best friends dread this more than even the shot of the enemy. "I do not fear the enemy's shot," says Mr. R. Napier in a letter to the Admiral, "so much as the risk of the shot from the turrets themselves when engaged against an enemy." The smoke of these turret guns lingering between the upper and spar-decks (independent of the results of shell exploding on the main-deck) will, undoubtedly lead to confusion in training the guns, and perhaps to the results so much feared by Mr. Napier.

* "Four such ships would more than suffice to realize the Mediterranean as a lake for our great neighbour; and close, in that direction, our intercourse with India. And four such ships would as effectually close the intercourse between France and Algeria. How would the alliance of such a force guarantee peace for all such as frequent the sea upon their lawful occasions."—*Halsted's Text Book*

We have not alluded to the armament of these proposed ships, or to the ingenious gun-carriage of Captain Heathorn,* because we do not believe that the project (which has doubtless, many good points) will ever become *un fait accompli.* To lower the turrets to the level of the main-deck (see cross section) and do away with the unarmored part altogether, would certainly improve them. To which changes may be added the substitution of twin, for single screws, and an arrangement of the horizontal iron in the backing so as to support the armor-plate. These vessels in outward form would then bear a resemblance to our own Monitors, and be better engines of war; but then they would not be the realization of the dream of Admiral Halsted. We have not hitherto adverted to the tonnage of these ships, and only do so now to illustrate the dreamy nature of the entire project. The tonnage of the largest—the "first-rate"—is nearly equal to that of the "Great Eastern," whose performances at sea hold out very little hopes of handiness to Admiral Halsted's customers. Two or three of the others exceed, by thousands of tons, the tonnage of the monster British iron-clads which have been universally condemned. The cost of one "first-rate," would be over $4,000,000, a sum sufficient to build and equip a dozen Monitors, with four 15-inch guns each—which with one salvo of shot—(23,520lb. weight) and the charges used at Shoeburyness, could easily sink the Admiral's entire fleet. If it be desirable in iron-clad ships, to combine a maximum of offensive power, with a moderate cost and a minimun risk of danger, then Admiral Halsted and his coadjutors have certainly missed the mark.

Our Monitors, whatever be their shortcomings, have seen some rough work and have done the nation good service. The European iron-clad has not often "smelt powder," and the English, especially,

* "*Muzzle-pivoting Gun-carriages of Captain Heathorn, R.A.*—These most valuable carriages are adopted for turret and broadside armaments throughout. They have great constructive merit.—1. In the simplicity and small number of parts.—2. In their capability for any required strength.—3. In their adaptability to all guns for all services; except boats, in which they would be needless.—4. In providing a minimum of port, with a maximum of training command, vertical and horizontal. The parts, though simple and few, as well as their action, are the product of practical mathematical application."—*Admiral Halsted's Text Book.*

has her spurs to win yet. The French floating batteries did some service at Kinburn, and the Danish, Austrian, Italian, and Spanish iron-clads have all been under fire. The British is still an experimental ship. We have endeavoured to describe its characteristics and capabilities fairly and without prejudice. About fifteen of Britain's iron-clads are wooden ships, and eight of the iron ships have sides of 15 to 18 inches thick, only, including the wood backing. These, including the three largest ships in the Navy, the "Minotaur," "Agincourt," and "Northumberland, are among the initiated spoken of as the "Egg-shell fleet," and in the event of a war would prove a source of weakness rather than of strength to the nation. The same may be said of at least half of the wooden ships. This state of affairs, evidently originating in the mistaken views of the Admiralty's advisers with regard to resistance to shot, seems to be duly appreciated in England, and doubtless has of late years greatly influenced the national leaning towards non-intervention.

No one who examines the products of British skill and labor as illustrated on the Champ de Mars, can doubt, for a moment, that English ship-yards can turn out iron-clads better adapted for naval warfare than any possessed by the British Government. Indeed they have already furnished such ships to other countries. But whatever may be the skill of the British mechanic and his powers of forging and bending iron to his will, that skill and these powers, in Government establishments, must be directed by men whose chief boast is that they know nothing of the laws by which the mechanic is guided, just as their ancestors in the Middle Ages boasted of their inability to read and write.

CONCLUSION.

In laying before the American Government and people, the results of a three months' inspection of the Munitions of War exhibited in Paris, we wish to say that we have been guided, first, by a desire to place before our country the most correct information on all the subjects touched upon ; and secondly to do justice to any article, invention, or design that seemed deserving of attention. That we may have overlooked some things really worthy of notice, is not to wondered at, considering the extent and variety of the collection, but we have not knowingly slighted anything of real interest. Desirous only of giving the best description of each exhibit as it came under consideration, we have availed ourselves of the labors of others, from time to time, and have acknowledged the source of our information. If, however, any omission of this nature has been made, through interruptions, or otherwise, we desire to disclaim any intention of having done so willingly, and once for all tender our best thanks to those by whose labors we have been assisted.

If a close study of the several branches of war materials herein discussed could enable us to give an opinion on the respective questions that come under our notice, we may venture to say that our countrymen have little to learn, and nothing to fear from European makers in the matter of Small arms. In light ordnance up to 7 inches in calibre, the Whitworth guns, for range and accuracy, would doubtless take the first place among all those exhibited in Paris. But in heavy ordnance, as well as in the design and construction of iron-clads, the European nations are still "at sea." The large rifle, in consequence of the erratic ricochet of its projectile, and its brief existence, is inferior as a naval gun to large smooth-bores, and few, if any, European iron-clads could successfully engage one of our Monitors armed with 15-inch guns. The rifled guns of the "Alabama," bore about the

same proportion to the smooth-bore cannon of the "Kearsage," as the large-sized rifle guns of England and France bear to our 15-inch cannon. The result of the combat between these two ships on the coast of France, and the power and endurance lately shown by the Rodman gun at Shoeburyness, if unheeded and unimproved by the Governments of France and England, cannot be to us a cause of regret. These events, while bearing testimony to the soundness of the policy hitherto adopted in regard to such matters in the United States, clearly indicate the path to be pursued in the future.

APPENDIX.

THE ROBERTS BREECH-LOADING RIFLE.

The Roberts system of breech-loading has been adapted hitherto chiefly to the Springfield pattern of gun. The barrel of the converted gun from the muzzle to the face of the breech-block is 37 inches in length with a chamber of 1¼ inches. This chamber has a uniform taper throughout, the maximum diameter being sixty-four hundredths of an inch, and the minimum diameter fifty-eight hundredths. The following is an extract from the inventor's description of the breech-loading arrangements as applied to a muzzle-loading gun of the Springfield pattern :—

"The breech-loading parts are five in number, and are made by hand, and screwed on to the rear end of the barrel. The first piece is a malleable iron breech-frame, that is screwed on to the rear of the barrel, and imbedded in the stock in the place of the old breech-pin. To effect this attachment, the rear of the old barrel is cut off about one inch in front of the cone, and a male screw reaching nearly to the rear sight of the barrel. The breech plug is inserted through this frame, and supported against the rear on a semi-circle concentric to the axis of motion. The centre of this semi-circle is the prolongation of the axis of the barrel. The rear of the breech-plug is turned to fit with exactness this semi-circle, and is played around it as a fulcrum. The chucks of the frame sustain the breech-plug laterally. When the breech-plug is in place in this breech-frame, it forms a curved lever, the handle projecting backward, and it then is moved about the solid concentric abutment of the frame, instead of being pivoted by any system of joints or pins, affording the greatest solidity and strength. The forward end of this breech-piece has a semi-circular groove, cut transversely through it, for the purpose of receiving a corresponding tenon, formed on a block of steel, termed the recoil-plate. The front of this block is flat, so that when in position it fits squarely against the vertical face of the chamber, and the rear end of the cartridge shell. A small space is left between the tenon on the rear of this block, and the front surface of the breech-block, above the transverse groove to admit of a slight rocking motion of the recoil-plate, so that it will descend to expose the breech of the barrel, and admit the cartridge into the chamber; this small open space permits the recoil-plate to descend perpendicularly, when the rear of the lever is raised, until the top of the plate passes below the axis of the barrel, after which it swings with the arc of the circle on the rear end of the breech-frame. When the rear of the lever is brought down to its place, the recoil-plate ascends to its position by the exact reverse motion, up to the axis of the barrel on a circular

motion, and afterwards to close the chamber ascending vertically and closing squarely against the butt of the cartridge shell, and the vertical face of the chamber.

The firing-pin is located on the right side of the breech-block and the recoil-plate, directed to the centre, for centre-fire cartridges, and grooved into the sides for the rim-fire cartridges. It is so set in on a shoulder, that the force of the blow of the hammer cannot drive it a greater distance than is necessary to insure fire.

The extractor is a curved lever fixed on the left side of the chamber, with one arm behind the flange of the cartridge, and the other operating in a vertical groove on the left side of the recoil-plate. When the lever is raised and the recoil-plate descends, the arm in the groove is not touched until the top of this plate reaches the bottom of the chamber; the shoulder at the upper end of the groove then strikes the lever and ejects the cartridge shell."

Instead of following the inventor's description further, we append the following extract from the Report of the New York State Board for the examination of Breech-loading Military Small-arms:—

"The guns presented for competition embraced the best systems invented, and the Board is convinced that all practicable methods of breech-block movement have been already applied and that future efforts in this direction must be confined to details or combination. Including both sessions of the Board, thirty-six distinct systems have been tested and seven others examined, and as these have comprehended every general principle applied either in this country or abroad, the Board feels confidence in expressing the opinion that no radical improvements over present systems is probable, and that future advance must be made in the direction of improved ammunition, or by a complete abandonment of present armaments and a substitution of entirely new weapons of warfare, our own great recent war and the hostile complications in Europe, have stimulated and directed in this channel the inventive skill of both Continents, and thus produced a rapid development."

In a *resumé* of the five classes into which breech-loading Arms are divided, the Report, referring to guns of the third class (*i.e.*, with the the breech-block, moving on a shoulder or pivot, at its rear end, dropping in the receiver below the chamber, for insertion of cartridge), says: "The only gun of this class presented at this session was the Roberts, which had been much improved since the previous session. The breech-block and appendages are readily removed without dismounting the entire piece, as hitherto, and a spring is applied to the firing-pin, retracting it when not pressed forward by the hammer. The lever should be further depressed so as to lie closer to the handle of the stock. The strength and safety of this arm, and its ease of manipulation and capabilities for rapid firing are conceded by the entire Board. The security of the breech-block as against accident by premature explosion, or the bursting of defective cases is indubitable. The ejection of the empty cases is accomplished as the inclined position of the breech-block facilitates ejection.

Original guns on this system while embracing all the advantages of the converted gun as tested, would also be capable of other important improvements. Generally it may be expressed that guns of this class from the peculiar system of the breech are eminently safe and durable, capable of sufficient rapidity of fire, and the objection that they are not adapted to the central-fire system of cartridges is sufficiently answered by the successful tests."

The conclusions of the Board in this case fully corroborate our own views of the relative merits of rim-fire and central-fire cartridges, as expressed in the body of our Report when speaking of the breech-loading competitions in England. In regard to the Roberts gun the following resolution expresses the decision of the New York State Board:—Resolved, that after careful and long continued examination and experiments, and in consideration of the combined qualities of strength, durability, safety, efficiency and economy, this Board deems the Roberts system of conversion of muzzle-loaders into breech-loaders as superior to all others examined, and recommends that the muzzle-loading arms of the State be converted to breech-loaders on the Roberts system."

THE BROUGHTON GUN.

THIS gun is the invention of Mr. John Broughton of New York, and though not in the Exhibition, it was shown in model to ourselves and others in Paris during the summer of 1867. Its action seems to be the very perfection of mechanism, combining, as it were, the rapidity of a magazine gun with the security of a muzzle-loader; and yet, the number of pieces or parts is not greater, but rather less than in the Remington and other breech-loaders of a similar class. There is, we believe, one spring more than is found in most American breech-loaders, but this spring is one which in the opinion of experienced gun-makers will outlast the gun itself, and is not liable to get out of order. Believing the Broughton gun to be entitled to the same consideration as we have given to other and similarly promising inventions, we shall as in other cases give the inventor's views of the principles embodied in his weapon in his own words. He says:—"In the construction of this rifle the following principles and considerations have been kept in view, and will be found embodied in the combination and arrangement of the mechanism:

1st. A breech-block in its opening and closing motions should move longitudinally in the line of the axis of the barrel, either by sliding in a groove, or by swinging on an axis; the swinging motion being preferable on account of its compactness and the ease with which it can be operated. All breech-blocks which open and close with a lateral motion either upward, downward, or sideways, require the cartridge in the act of loading to be pushed clear into the barrel by the finger or thumb of the operator before the breech-block can be closed. This is a serious defect, particularly when the fingers are cold and benumbed, or the cartridge is so large that it fits tight in the bore of the barrel, the cartridge also is liable to become jammed by the sudden closing of the breech-block, and under any circumstances it is an operation necessarily slow, and one that requires a degree of attention not likely to be given to it under the excitement of rapid and continuous

firing. The longitudinal swinging motion, on the contrary, merely requires the cartridge to be partially inserted in the bore of the barrel, after which the closing motion of the breech, operated by a powerful lever, forces it clear into its chamber with ease and rapidity, and without the slightest attention on the part of the operator.

2nd. A downward and forward motion of the hand in the line of the barrel to open, and a backward and upward motion in the same line to close, are the simplest, and most direct, and quickest motions that can be made in the opening and closing the breech mechanism of a gun.

3rd. The locking device combined with a longitudinally moving breech-block, should be operated simultaneously with, and by the same motion that opens or closes the breech-block. Breech-blocks which move in the line of the barrel, but require a lateral or distinct motion to lock and unlock them, are defective from the fact that they require two unnecessary motions when the breech is open and in the act of loading; while the longitudinal motion to close the breech is easy and rapid, the lateral motion to lock it is both awkward and difficult, and under the excitement of continuous firing, this motion would be sometimes only partially made, in which case the breech would be but partially locked, and liable to be blown open when the gun was fired.

4th. The combination and arrangement of the swinging breech-block, the locking device and the hammer should be such, that the hammer cannot fall and explode the cartridge without the breech-block being securely locked.

5th. The arrangement of the breech-block, the locking device and the hammer, should be such, that the breech-block cannot be opened and a cartridge inserted, without the opening motion serving to put back the hammer to the safety position of half-cock, at which position it should be left when the breech-block closes.

6th. The arrangement of the breech-block, and the locking device, should be such, that when acted upon by the explosion, the recoil will tend to lock them more firmly together.

7th. The arrangement of the locking device and the hammer should be such, that while the hammer in its fall will force the locking-brace to enter its proper position (provided it has not already done so) before the cartridge can be fired, yet when the breech-block is closed and locked, it should remain securely locked independent of the hammer, thus enabling the hammer to be moved by the thumb to any position, irrespective of the locking of the breech, and merely requiring it to perform the ordinary function of firing the cartridge.

8th. The arrangement of the mechanism to be operated by the thumb or finger in the act of opening or closing the breech, should be such as to be capable of easy and rapid manipulation. A slight pressure of the thumb applied to the operating lever of this gun, exerts a considerable and ample force to unlock and open the breech and withdraw a tightly expanded cartridge-shell from the bore of the barrel. This is accomplished too, with a range of motion to the lever, which leaves it within easy reach of the fingers when grasped with the thumb resting on the top of the stock for the closing motion.

9th. An extractor to be perfect in its operation should take a broad and firm

hold of the rim of the cartridge-shell and move longitudinally in the direct line of the barrel, so as to be in contact with the rim of the shell during the entire motion of the extractor, and compel a tightly expanded shell to be withdrawn without the possibility of slipping or cutting through the rim. Its motion when the breech is fully open should be suddenly accelerated, so as to throw the exploded shell clear out, without the necessity of elevating the muzzle of the gun or requiring the shell to be picked out with the finger and thumb.

10th. Similarity of action or motion in all the moving parts, and all moving in the same plane or direction, is conducive to ease and rapidity of operation. The distinguishing feature of the entire breech mechanism of this gun consists in its being arranged and constructed to operate on the principle of rotation, by which means the parts in the act of opening the breech all vibrate in unison together with a smooth and easy motion; thus the advantages of simplicity, strength, compactness, ease, and rapidity of operation are obtained and combined to the fullest extent, and the fewest possible motions are made in the act of loading and firing. When the breech is closed no opening is presented on the exterior surface, (even when the hammer is at full cock,) into which dust and dirt can enter to clog the mechanism. The parts themselves are few in number, and while they are comparatively light, they are all substantial and strong, not liable to wear or break by ordinary use, and the entire fire-arm is plain and symmetrical in appearance."

The inventor gives what appear to be cogent reasons in favor of each of the principles here laid down, and illustrates their value by arguments drawn from the defects of other systems of breech-loading. Into these controversial points we have no desire to enter, and shall conclude our notice of this new weapon by quoting the inventor's descriptions of the movements necessary in loading and firing.

"In loading and firing, the movements are as follows:—Supposing the gun to have been loaded and the first shot fired and the operation to be continued as rapidly as possible, then full-cock the hammer with the thumb, while lowering the gun from the shoulder to the loading position. Pass the thumb from the hammer down into the rear loop of the lever, and swing it quickly forward to open the breech and extract the shell. Push in a cartridge until it comes in contact with the extractor; close the breech by a squeezing action, the thumb being on top of the stock and the fingers extended down in front of the lever. Raise the gun and fire. The raising of the gun and closing of the breech may be simultaneous.

"If the gun is intended to be loaded and not fired immediately, the hammer need not be moved with the thumb. The motion of the operating lever in the act of opening the breech will half cock the hammer, and when the cartridge is inserted and the breech closed, it will be left at its safety position.

The motions in loading and firing being of the character termed 'easy and natural,' a very little practice makes the action of lowering the gun from the shoulder, cocking the hammer, and opening the breech, approximate very closely

to a single and continuous movement. So also the action of closing the breech, raising the gun and firing; hence for ease and rapidity in loading and firing, this gun is not excelled, (if equalled,) by any other single loader."

THE GATLING BATTERY.

The inventor of this weapon referring to the guns tested in France and England during 1867, says: "I wish to state that the Gatling Battery guns of six barrels exhibited in the Paris Exhibition, and tried at Versailles, as well as these used in the trials at Shoeburyness, and at Fortress Monroe, have, together with the ammunition, been greatly improved since these trials were made. Improved Gatling guns, of one inch calibre with ten barrels, are now being constructed at Colt's Armory in Hartford, which can be fired at the rate of 200 rounds per minute. These guns discharge half-pound solid lead-balls, and have an effective range of 2,500 *metres*, or say, one and a half English miles. Another class of the same weapons, also with ten barrels and of half-inch calibre, are now making at the same Armory; these have been fired at the rate of over 300 shots per minute. The trials of the Gatling gun at Shoeburyness were made under the most unfavorable conditions. The gun used on that occasion was very imperfect both in material and workmanship, the firing pins were made of hard steel, and one of them was broken before the commencement of the trial. Thus the gun was tested in a disabled condition against an Armstrong gun, and that too by men who were unacquainted with its use, and who were quite familiar with the Armstrong. The ammunition was also very defective. Two of the six barrel, and one of the ten barrel improved guns with new ammunition have been tried lately at the target grounds at Versailles. At one of these trials the Emperor attended, accompanied by the Minister of War and several distinguished officers of the French army. On this occasion the president of the Artillery Commission reported, that, "The service of the one-inch gun was excellent at 2,400 *metres*, and indeed exceeded his expectations."